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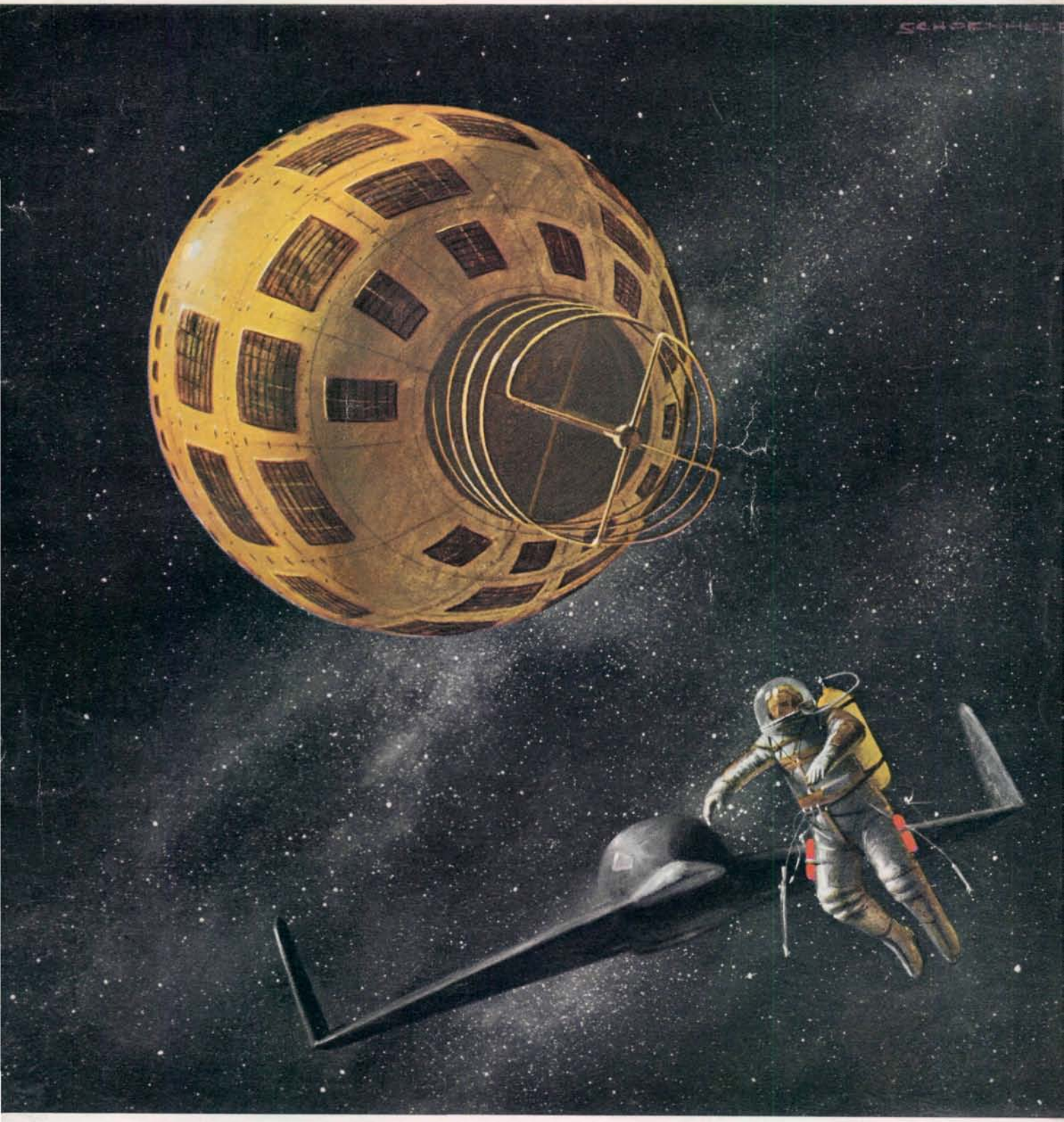

THE TROUBLE WITH TELSTAR | BY JOHN BERRYMAN

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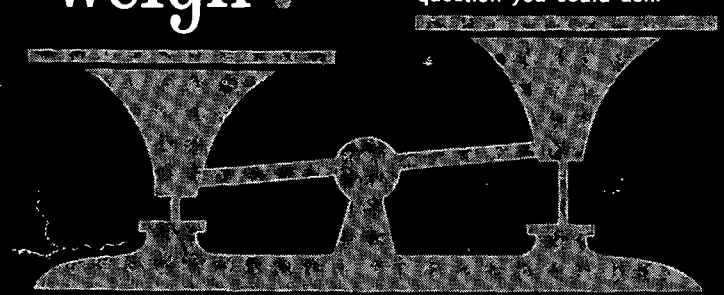

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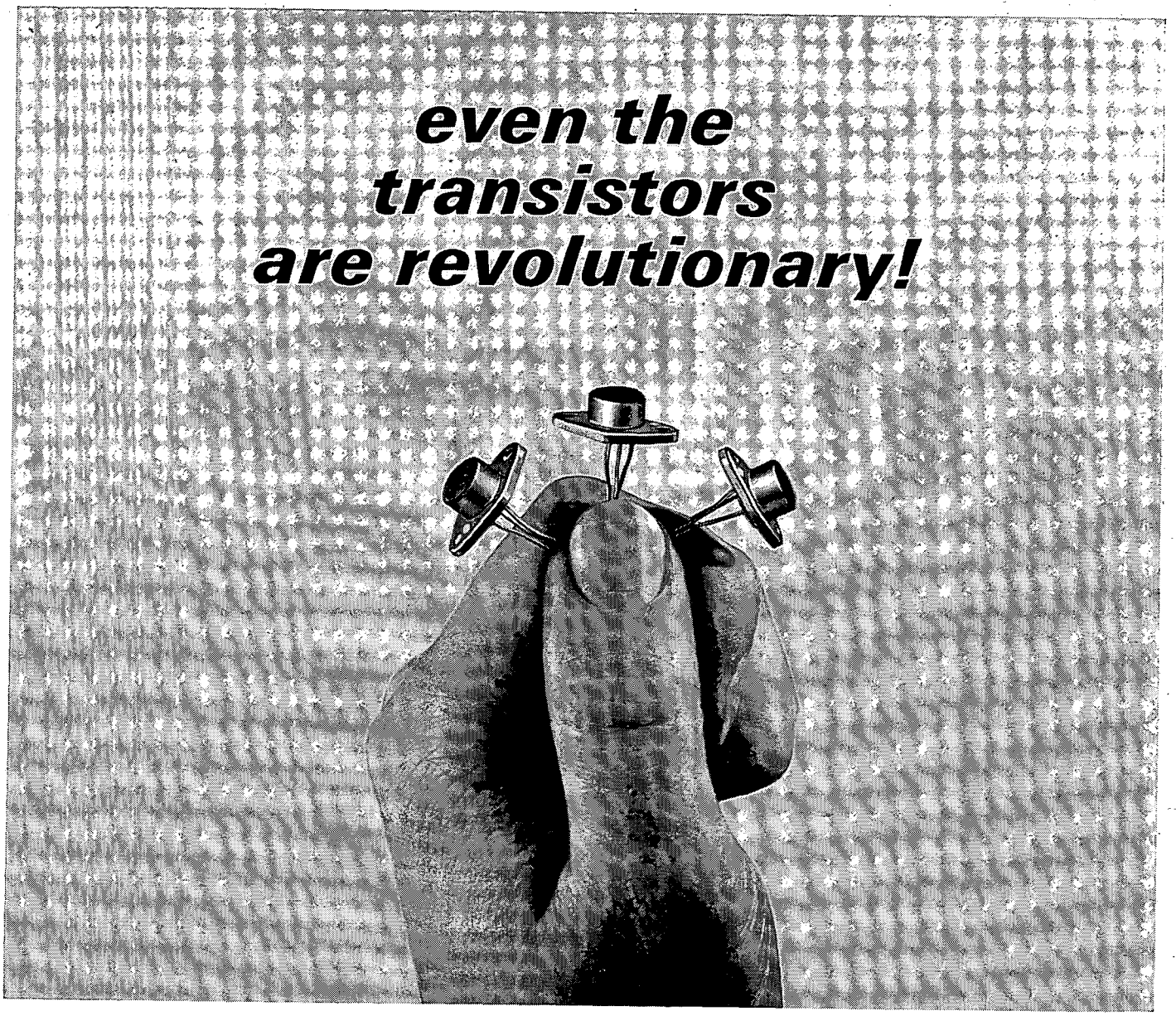
even the transistors are revolutionary!



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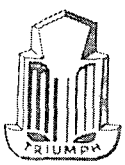

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COVER BY JOHN SCHOENHERR

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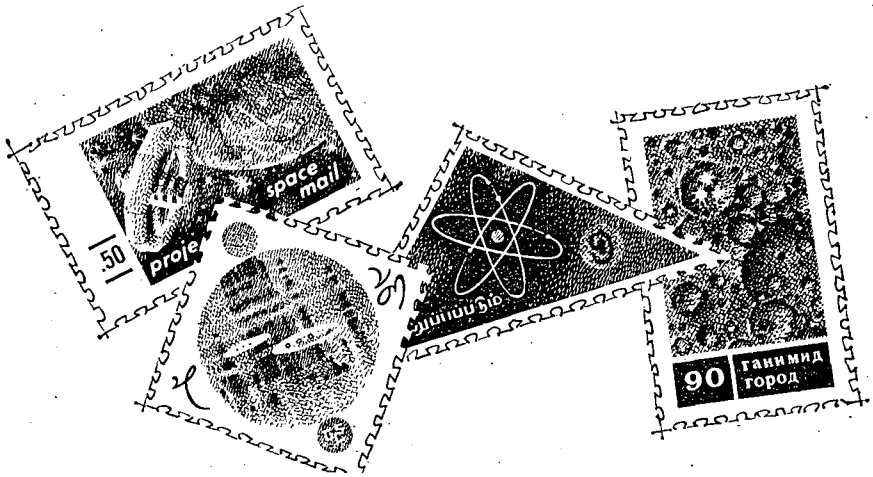

BRASS TACKS

Dear John:

Your questioning the reason for the apparent discrepancy in missing the crop-destroying freeze in Florida stimulated a check.

Here are the data:

a. 70% of the celestial bodies are in south declination, below the equator. This is the big harbinger of a bitterly cold, arctic winter in the eastern third of the nation. This was a fairly easy interpretation when you consider certain geocentric longitudes, latitudes and declinations.

b. Mars, which correlates with *heat*, we knew would be *southing* in Leo (more heat).

Merely considering the above two celestial phenomena, we interpreted that Mars in Leo would mitigate the cold in the south. These are the elements one must learn to balance, synthesize and judge to render accurate interpretations. The fact that Mars southing in Leo did *not* protect the southern United States from a near-disastrous freeze doesn't invalidate the idea of planetary influence on our weather.

In fact, I'll go so far as to revise the forecast for the south. The very fact that one element didn't work as I thought it would now indicates *disaster* in the Deep South when the Winter Solstice occurs.

My uncertainty about the mitigating influence of a single planet—and subsequent wrong choice—has resulted in our learning something new in astro-meteorology. You rarely get a chance to check the planets in these positions.

What disturbs me now is the fact that once the crop is harvested, they'll think that's that—and relax. Few Florida homes are built to withstand the cold we get up here. They don't stock up fuel in the winter. Most vacationers have no warm clothing. I expect some people will freeze to death.

JOSEPH GOODAVAGE

■ *There's a lot to learn, whether the astro-method works or not!*

Dear John:

One of the jobs of Science Fiction, as I see it, is to discuss not only Technology, but the problems induced by Technology. (Pardon the capitals, but everybody seems to be doing it now!) Well, in the letter columns, and in the stories, Analog has discussed such far from imminent problems as ESP, the Dean Device, and what not. But it has *not* discussed the biggest problem coming up.

Automation. How do you run a society in which the only *needed* people are Ph.D.'s, computer programmers, and top-flight artists? Manual labor is on the way out. Routine office work is following. Don't tell me you can train the superfluous to become creative. You know it can't be done. Remember Sturgeon's Law—"ninety percent of anything is crud."

This is a problem that is in our laps. Kurt Vonnegut had a try at it in "Utopia 14," of "Player Piano," but I should like to see one of the main stream SF writers see what he can do with it. If there is any place where a reasonable solution might be worked out, it is in the columns of Analog. And I say this in spite of the many times that your opinions have convinced me that you should be certified.

JOHN D. CLARK

■ *So why don't you do it? Been some years since you wrote for Astounding, and time you did something for Analog!*

Dear Mr. Campbell:

"Code Three" sounds pretty logical as an idea of a super-super-highway superpatrol car. However, I am afraid that ten-day trips at high rates of speed might leave the crews prone to murder each other on the least excuse. Emergency duty in this day and age is hard enough on the nerves for short tours of a day or less, in one city, especially where a lot of gory work is common.

As for the gear, torches are getting less common, except for slicing bars too thick for bolt cutters. Hydraulic opening sets to jack up or separate parts are getting quite a play, having much muscle and small fire hazard. Where flammable vapors are present, torches are a fine way to start something.

Chances are that the "chemical fire-fighting liquids" of the future will still lean heavily on good old H_2O for several reasons. It is cheap, available, noncorrosive, nonpoisonous, and in general seems to be tailor-made for many jobs besides drinking and bathing. Some people think water is old fashioned, but there is little chance it will go out of date till freezer rays come in. We presently have a number of liquid additives which give penetrant in one mixture, and foam in another. Car 56 would no doubt have a few main tanks of water and tanks of chemical foams tailored to different duties, such as magnesium

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fires, petroleum products, penetrants for densely baled materials, et cetera. A vehicle of the dimensions stated could haul a respectable amount of stuff.

Conversation will no doubt lean toward the "10-4, 10-20" side, for obvious reasons. At high speeds, the short phrases of number codes would get the dope across fast, and with three nations involved, three main languages, and many local dialects of them, the simpler the talk, the more chance it will be clearly understood. But here, if Raphael had invented a code, he'd have to include a guide to it for the reader, so this is just nit-picking.

With present speeds, chases are a hell of a mess. Today a car in Dayton, Ohio, hit 105 miles per hour, glanced off a patrol car, ran through a house and started a fire that burned the house down. It is a source of wonder to many firemen that speeders can stop without the aid of hydrants, too. Picture some yokels doing 500 per away from the bank!

I wonder what would result if Raphael would work on a fire crew of one hundred years hence? Recently a salvage firm disclosed plans for salvage ships for high seas fire-fighting and salvage, which will carry a remote-controlled track-type fire-fighting vehicle. A tanklike vehicle with heavy armor and thick shielding could work where present fire trucks couldn't. See that picture of the Philadelphia ladder truck where the wall fell on it? Hazard #1.

JOHN P. CONLON

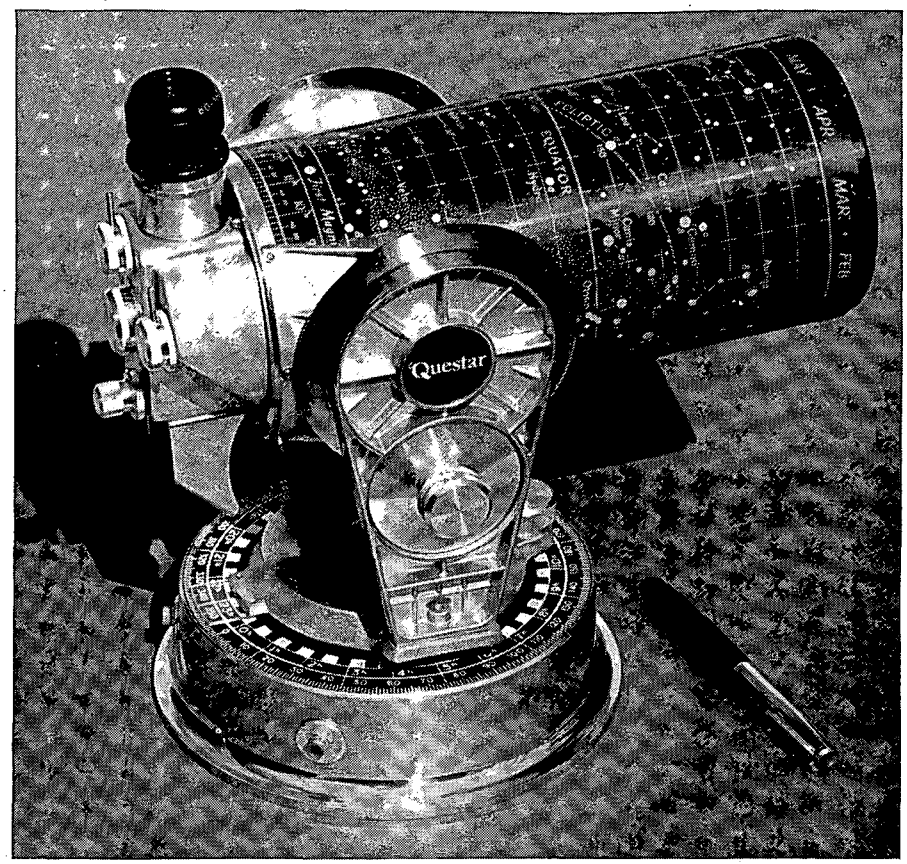
52 Columbia Street,
Newark, Ohio.

■ *Rick Raphael's planning more Patrol stories—and your comments belong in them!*

Dear John:

You have argued for a place where all scientific and technological ideas can be presented; no matter what the source, no matter how controversial. O.K., here it is:

Continued on page 93



Although most of our sales are to individuals, every week we ship more and more Questars to laboratories and special projects, great and small. When reorders come in we wonder what new and fantastic uses are being found for the instrument we are so proud to make and sell. We know but few of these, but we have learned from enthusiastic users that Questars do follow missiles, find and photograph re-entering nose cones, and take high speed pictures of tiny particles. Where exploding wires formerly fouled a near lens, Questars now record the event from the far side of the room. They feed all sorts of motion picture cameras and color television devices. The latest operating theatres here and abroad plan to build in Questars for closed circuit viewing of surgery.

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THE INTERNATIONAL LANGUAGE

EDITORIAL BY JOHN W. CAMPBELL

Of all the languages of Earth, English comes closest to being in fact the international language. Whether it be full English, or the cut-down versions Pidgin or Basic or Broken, more people can speak and understand a useful degree of English than of any other language.

Now let's look for a moment at why this *should not* be so.

Of course, English has the world's worst spelling. It also goes in for constantly varying, rather than discrete-definite or quantized, vowels. The simple word "out" is not, truly, a monosyllable, nor is it bisyllabic—it just slumps gradually from an "ah" sound to an "ow" type vowel. This makes it impossible to spell English accurately, if we use any reasonable number of vowel symbols. And makes it very difficult for Spanish-speakers, for example, who have quite discrete and definite vowel sounds, to learn the English vowel-slump. (The word "vowel" itself, incidentally, has essentially the same sound pattern as "out"—yet "vowel" is considered bisyllabic. Try "owl" with a "v" sound in front.

English grammar, moreover, is even more light-heartedly and illogically whimsical than that of most other languages.

The whole organization of the language appears to be dominated by a desire for a maximum of illogicality. It has the largest vocabulary of any language in the world—and on top of having more different sound-symbols, still uses one sound-symbol for several different meanings, to add to the irrationality of the language. This combination of insanities triumphantly produces the situation of a valid English sentence that *can not* be written correctly: "There are three *toos* in the English language," is one of the incorrect forms. There is no correct way of writing it in English—though it can, of course, be phonetically transcribed.

Moreover, English grammar is so fantastically structured that even English grammarians haven't figured it out yet.

For instance, there are two forms of the present tense of English verbs. To take a synthetic verb for illustrative purposes, *to larb* could have the forms "I larb," or "I am larbing."

Most English grammar texts make

Continued on page 94

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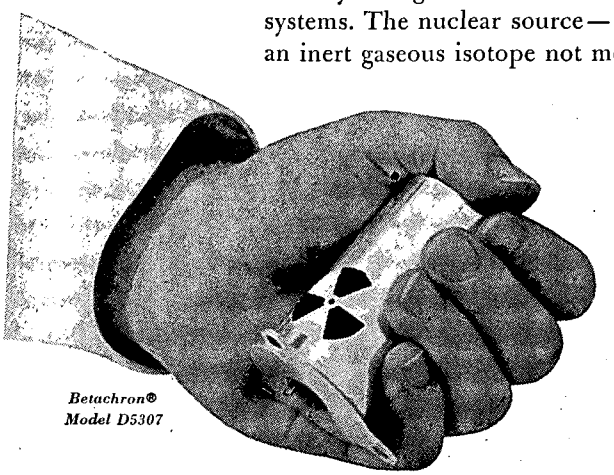
STATUS REPORT ON SELF-POWERED AEROSPACE DEVICES

Nuclear-Powered Components: The availability of a miniature nuclear source has made possible an entirely new genre of devices . . . that of self-powered components for aerospace systems. The nuclear source—the Leesona Moos Krypton 85 Battery—contains an inert gaseous isotope not metabolized by the body and quickly dispersible in air should the battery be damaged. As a result, the battery is a very practical as well as reliable unit, delivering in excess of 10,000 volts, charging linearly to 1,000 volts, and having an operating life of over ten years.



Betachron® Model D5307

■—As would be expected, the advent of such a power source has been accompanied more recently by a new wave of components designed around it. Most of the new Leesona Moos components are aerospace-type transducers: small, lightweight, self-powered.

■—*Example I:* the Betachron® Model D5307. This is an acceleration-actuated delay timer which senses uniaxial acceleration, initiates a time delay when a certain predetermined g force has been reached, then delivers an electrical signal to the load. The time delay can be set for a minimum of 15 seconds and the maximum is limited only by duration of acceleration. Should the g level fall below the set value before the time delay is complete, the device automatically resets itself. With its highly reliable service life of 10 years, plus its unusual characteristics, the Betachron D5307 has found a number of aerospace system applications, such as data package release, parachute release, weapon sterilization, and actuation of satellite transmitters or other equipment.

■—*Example II:* The Ionoswitch™ System. This device senses altitude as a function of air density differential, initiates a time delay at the pre-set altitude, then delivers a capacitor discharge or closes a switch. It contains only one moving part and can be set for altitudes from 0 to 250,000 feet. The applications of the Ionoswitch Altitude Sensing System include stage destruct, stage separation, package release, re-entry body release, and other similar aerospace uses.

■—These are but two of a new group of self-powered aerospace devices. All are characterized by ruggedness; being unaffected by shock, vibration, or temperature cycling, and usable or storable for a period of more than 10 years, they offer a high order of reliability. Because the battery isotope is a beta emitter, only routine low-level-radioactivity handling is required. For data on these and many other novel aerospace components, both nuclear-powered and non-nuclear, write Leesona Moos Laboratories at Dept. 63.

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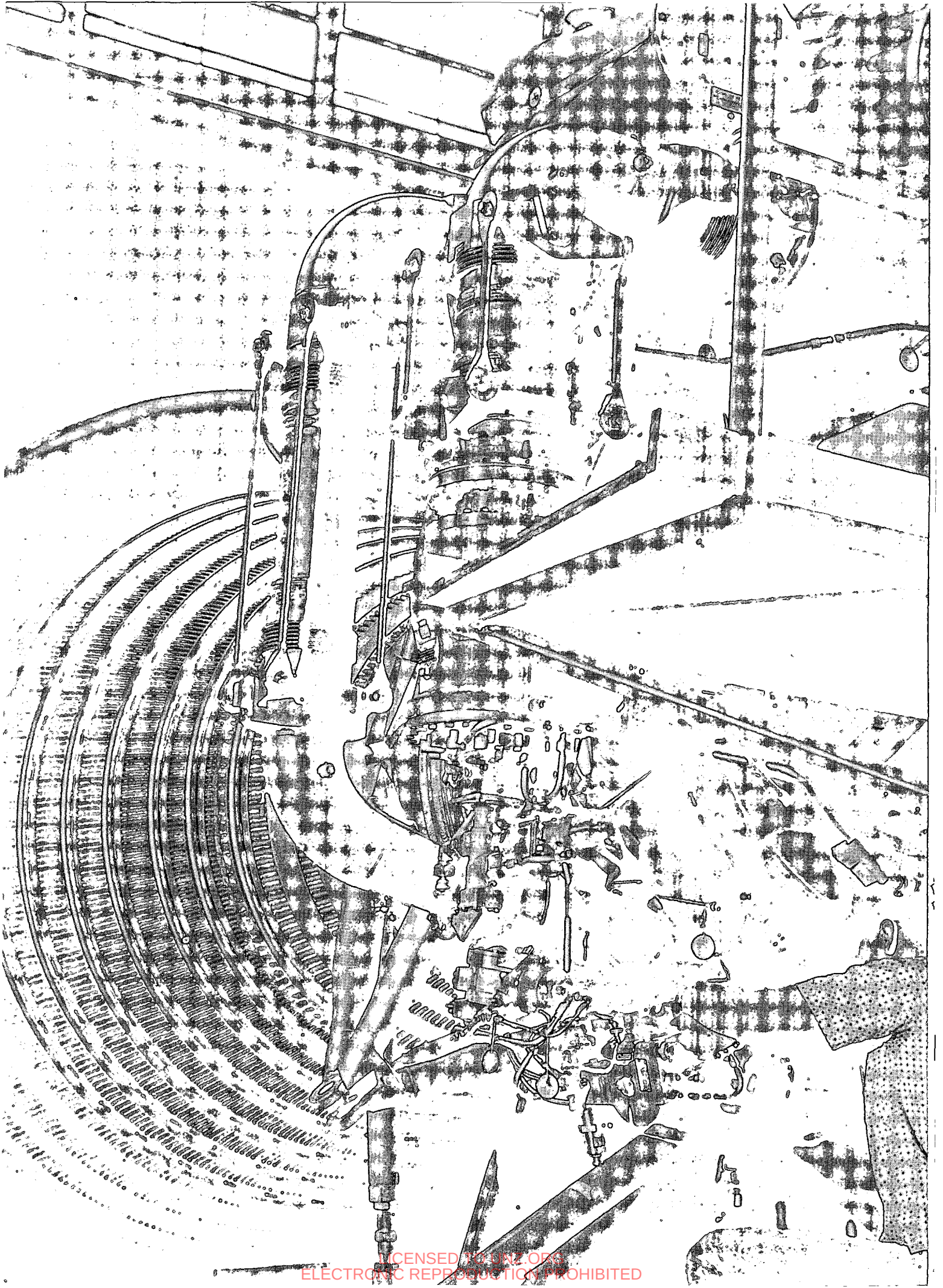

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THE BIG FUEL FEUD

The rocket business started with solid fuels —so, says one side, solids are old-fashioned. But, says the other side, liquids won't wait, they're leaky. So . . . .
The Great Fuel Feud is on!

BY HARRY B. PORTER

From the tradition-fogged banks of the Potomac to the smog-shrouded suburbs of Los Angeles, and from the salty soil of Utah to the humid humus of Alabam', a controversy of space-shaking proportions is going on. Wherever rocket men gather—at conferences, coffee breaks, or just plain bull sessions—the discussion usually gets around to the relative virtues of solid and liquid propellants. The general public has heard only an occasional rumble—and out here in California they blame *that* on the San Andreas Fault—but everyone in the rocket field is aware of the technical tussle, and of the possible effect of its outcome on our Lunar Landing Program.

Actually, the difference of opinion is of long standing. For the past quarter century, there have been innumerable articles, papers, and symposia—some of them rather heated —on the question of which type of propellant is superior: solid or liquid?

The series of events that brought the matter to a head really began with President Kennedy's address to a Joint Session of Congress on May 25, 1961, when he said, "We propose to develop alternate liquid- and solid-fuel boosters, much larger than any now being developed, until certain which is superior." At that time, it was generally understood that solid and liquid super-boosters for the Apollo program would be developed concurrently, and the president's words only confirmed that impression.

A half year later, it was announced that the United States would henceforth rely on a rendezvous program employing liquid-propellant boosters with the liquid-propellant Nova—Earth-Moon non-stop—rocket as an alternate approach to the initial lunar landing of a manned vehicle. This, of course, meant that the solid-propellant super-booster was demoted to a low-priority status—in fact, it apparently would no longer have any status at all in the Lunar Landing Program. Needless to say, the solid-propellant people were somewhat dismayed by the announcement, and some of them expressed their displeasure in no uncertain terms.

All this does not mean that solid propellants are out of the space picture entirely. At the time of this writing, however, it appears—from official news releases—that no major effort will be expended on the development of large solid-propellant boosters for space work before 1964. Of course we know that anything can happen in our Space Program—and usually does. Polaris and Minuteman have proved the feasibility of large solid-propellant motors, and solids will no doubt find many uses in future space activities. At least until

Fig. 1: An F-1 liquid-propellant engine is given a final adjustment before test-firing. This engine, which develops a thrust of 1.5 million pounds, is the most powerful rocket engine this side of the Iron Curtain, and may well be the booster for the first manned lunar expedition. The assembly above the engine is the turbopump which delivers propellant to the combustion chamber at the rate of three tons per second. Note tubes for regenerative cooling of the nozzle at left. Solid-propellant backers claim that liquid-propellant engines are unreliable because of their complexity. Liquid propellant rocketeers point to thrust control, steerability, higher specific impulse, and other advantages.

Photo Courtesy of Rocketdyne.

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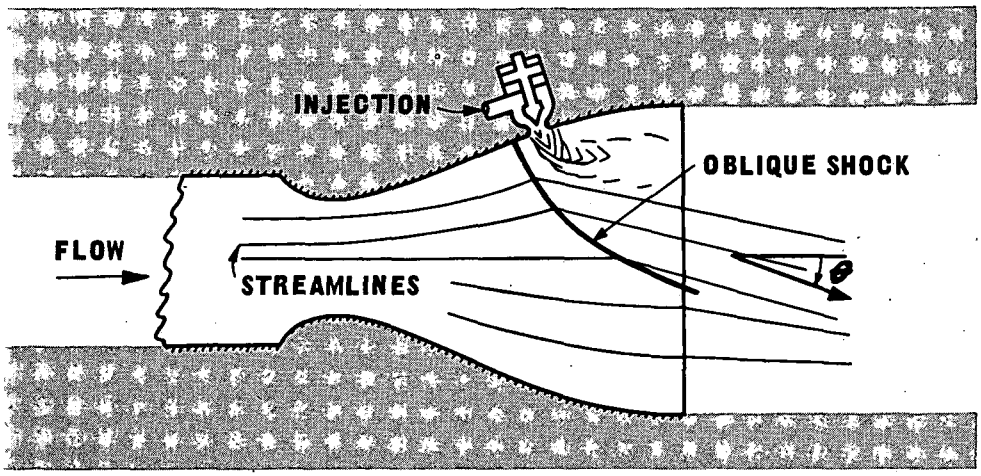

Courtesy of United Technology Corporation.

Dick Tracy and his pal Diet Smith decide to reveal the details of their Space Coupe!

The main points around which most of the controversy between the advocates of solid-propellant and liquid-propellant rockets revolves are: relative simplicity of design, manufacture, and operation; reliability; capability of firing for long periods of time; practicability of thrust vectoring, thrust control, shut-off, and re-ignition; specific impulse and thrust magnitude; propellant density; sensitivity to variations of temperature and pressure; storability; and safety.

It is undeniable that solid-propellant motors are much simpler than liquid-propellant engines. This is so mainly because of the necessity of providing the latter with: (1) pumping systems for the fuel or oxidizer, or both; and (2) a metering device for controlling the flow of liquids to obtain the proper fuel-oxidizer ratio. Solid propellants, of course, have the optimum fuel-oxidizer ratio "built in". Where a solid-propellant motor may have three or four moving parts—or none at all—its liquid-propellant counterpart may have several thousand!

The multiplicity of parts, especially of moving parts, adds to the complexity of manufacturing liquid-propellant engines. One's first view of the innards of an LP engine usually leaves one with the impression of a plumber's nightmare—in Technicolor! On the other hand, except for improvements in design, most of which are not immediately obvious to a casual observer, modern solid-propellant motors—even the really big ones—are not much different from those of fifteen or twenty years ago. They are still, essentially, thin-walled tubes filled or partially filled with propellant closed at one end and having a nozzle at the other. Obviously, solid-propellant motors are the simpler to manufacture.

As for simplicity of operation, solid propellants ignite with little or no difficulty. The same cannot be said of liquid propellants. Once ignited, solid propellants burn to completion—in fact, there is little that can be done to change things after combustion is established. On the other hand, a foul-up in the metering or pumping systems can easily result in failure of liquid propellants to burn efficiently, or to burn at all. The transportation of solid-propellant rockets, especially the larger sizes, is somewhat more difficult and harzardous than that of liquid-propellant rockets. The latter are shipped empty, which means they are lighter, and

Fig. 2: Diagram illustrating the principle of thrust-vector control by secondary injection. When injected into the nozzle under pressure, the liquid generates an oblique shock wave which changes the direction of the exhaust stream—and thrust—providing a means for steering the rocket. This system is especially applicable to solid-propellant rockets.

Fig. 3: An Atlas ICBM blasts off at Vandenberg Air Force Base. Note steering jets near the aft end. The entire missile is sheathed in water vapor condensed out of the air by the intense cold of the expanding oxygen as it escapes from the pressure-relief valves. Rockets using cryogenic propellants must be fueled immediately before launching.

Photo Courtesy of General Dynamics.

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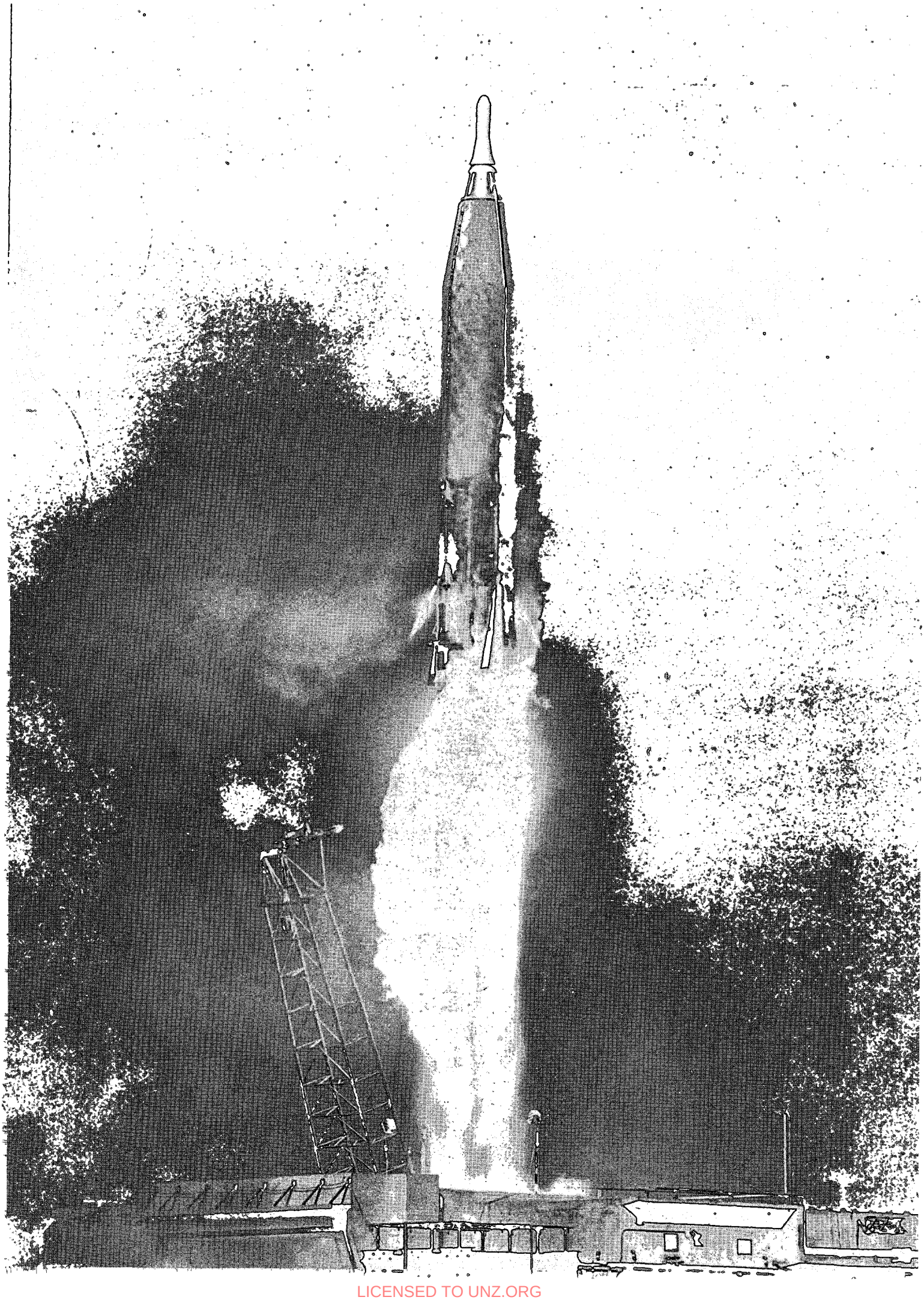

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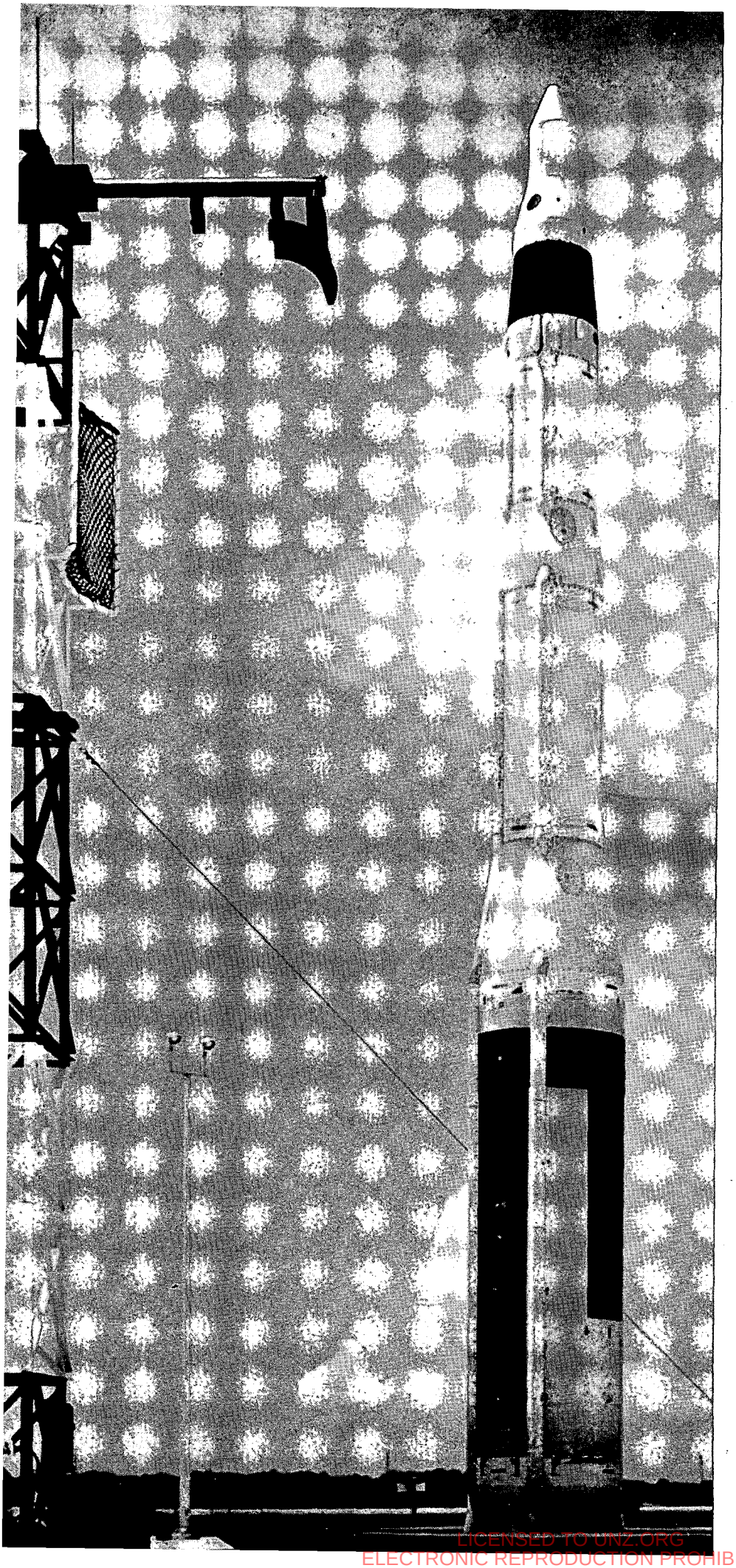

all one has to worry about is the hardware. Servicing solid-propellant rockets in the field is more hazardous, because the work must be done on loaded motors. Liquid-propellant rockets are not fueled until just before firing.

The question of reliability has been the subject of discussion for a long time. It is generally conceded that reliability and simplicity go hand in hand. Obviously, the more parts involved, the more opportunity there is for failure. Even the liquid propellant people have, in the past, been forced to admit that solid-propellant rockets were the more reliable. Recently, however, they have been pointing to House Report No. 67, which contains a record of United States missile firings to February, 1961, which they contend proves that, in missiles of comparable size, liquids are as reliable as solids. At the time of this writing, the argument on reliability is extremely hot and shows no signs of cooling off.

The firing duration of which a rocket is capable is limited to the length of time its nozzle and combustion chamber can hold up under the combined effects of high temperature and high-velocity gas erosion. One of the advantages that liquid-propellant motors have is that they can be fired for long periods of time. This is not due to any special virtues of liquid propellants, as such, but merely to their being liquids—which makes regenerative cooling possible.

In regenerative cooling, either the fuel or the oxidizer is forced to flow

Fig. 4: America's Minuteman ICBM stands on its Cape Canaveral launching pad. Minuteman is a monument to solid-propellant technology—proof of the feasibility of really large operational solid-propellant rockets.

Photo Courtesy of Thiokol Chemical Corporation.

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through channels around or inside the walls of the combustion chamber and nozzle before entering the combustion chamber itself. The heat that it absorbs along the way cools the nozzle and chamber walls. There is little or no energy lost by the system thereby, because the absorbed heat is carried back to the combustion chamber where it originated, and contributes to the production of thrust. Of course regenerative cooling does not make it possible to fire the motor for an unlimited period of time, because mechanical erosion caused by the high-velocity impact of exhaust-gas molecules still goes on regardless of the temperature. However, it does increase the firing duration to many times that of an uncooled nozzle and chamber. It is not at all unusual for liquid-propellant test motors to fire continuously for half an hour or more.

In most of the smaller solid-propellant rockets, the nozzles are uncooled. In the large ones, often the nozzles are cooled either by a thin film of liquid introduced just upstream of the nozzle entrance cone, or by ablation. Ablation or, more properly, *ablative cooling* consists in providing the nozzle with an inner lining of a material that decomposes endothermically, or that absorbs heat as a result of fusion and vaporization, or both. Ablative cooling is not as effective as regenerative cooling, but it slows the temperature rise enough to permit firing durations of two minutes or so. Solid-propellant combustion chambers—or motor tubes, as they are called—are not cooled. They are usually protected by a lining of thermal insulation, but even this is not really necessary if the charge is of the internal-burning type—as the really big ones always are.

Thrust control (regulation of the amount of thrust), thrust vectoring (an impressive term for controlling the direction of thrust for steering the rocket), shut-off, and re-ignition are all fairly simple with liquid propellants. Thrust control and shut-off are accomplished by means of valves for regulating the flow of propellant liquids to the combustion chamber. The most popular method of thrust vectoring is to swivel the entire nozzle-chamber assembly to point in different directions. Re-ignition is most easily accomplished by using hypergolic liquids: i.e., liquids that ignite spontaneously on contact. It is then only necessary to re-open the valves and allow the liquids to resume their flow into the combustion chamber.

So far, the only proven practical method of thrust control for solid-propellant rockets is by designing the charges to burn in such a manner as to "program" the thrust. This means that the required thrust at all times during the flight must be predicted accurately, since nothing can be done to change the programming after ignition. Thrust vectoring may be accomplished in several ways, by jetvanes placed in the exhaust stream, by jetavators placed *around* the exhaust stream, by movable nozzles, by separate steering rockets, and by nozzle boundary layer shock. The last-mentioned method consists in creating a shock wave in the exhaust stream to cause thrust misalignment. The rocket is steered by controlling the direction of the misalignment. One way of doing this is to inject a liquid into the exit cone of the nozzle —secondary injection. All of these methods, except the use of steering rockets, are terrifically rough on materials. Jetvanes, for example, are the most efficient from the standpoint of steering, but they are in the exhaust stream all of the time, so they take a terrible beating.

Shut-off, or thrust termination, can be accomplished by quenching with water carried along for the purpose or by blowing the nozzle off with an explosive charge to reduce the chamber pressure below the minimum value at which the propellant will burn. Several schemes for re-igniting solid propellants have been proposed, but none has yet been accepted by rocket engineers—as of the date of this writing. However, a considerable amount of effort is being directed toward a solution.

At the present time, some of the liquid bi-propellant systems—those that employ a liquid fuel and a liquid oxidizer—can develop specific impulses about sixty-five per cent higher than the highest produced by solid propellants. In the larger liquid-propellant rockets, the maximum thrust levels are also somewhat higher than those of solid-propellant rockets of comparable size.

The densities of solid propellants are higher than those of liquids. This makes it possible for solid-propellant rockets to attain a higher mass ratio—weight when fueled/weight empty—which, in turn, means a higher burnout velocity.

The performance of solid propellants is affected more by variations in temperature and pressure than is the performance of liquid propellants. In hot weather, solids burn faster and produce higher thrust than they do in cold weather. Although the thrust level is higher in hot weather, the burning time is correspondingly shorter, so the specific impulse is not increased. Where accurate thrust programming is essential, allowance must be made for temperature effects. Extreme cold may cause ignition failure or poor combustion. It may also cause cracking of the propellant as a result of unequal shrinkage and subsequent expansion upon firing, which can, in turn, lead to a blowup. Extremely hot weather may soften the charge to such an extent that it cannot withstand the sudden internal pressure rise at ignition. This can also result in propellant cracking and motor blowup.

Solid propellants, in general, are storable; that is, they can be stored for long periods, either as grains or loaded in rockets and ready to fire. Certain storage, or "canned" liquid propellants have also been developed —fuels such as unsymmetrical dimethyl hydrazine (UDMH), unsymmetrical diethylenetriamine (UDETA), ammonia, and various amine mixtures, paired with oxidizers such

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as nitrogen tetroxide, hydrogen peroxide, RFNA, and IRFNA—RFNA inhibited by the addition of a small amount of hydrogen fluoride. Some liquid-propellant combinations—for example, UDMH and IRFNA—exhibit even better storability than the most storable solids. However, the liquid propellants giving the highest specific impulses—the "exotic" propellants—are of the cryogenic type: i.e., liquified gases that must be kept at very low temperatures. As such, they can hardly be considered storable.

With the exception of danger from fire during transportation and field servicing, solid-propellant rockets are usually considered safer than liquid-propellant rockets. Solid propellants are noncorrosive and nontoxic, although some people develop sensitivity to them after working with them for an extended period of time. Most solid propellants burn poorly or not at all at atmospheric pressure, so, in the event of a blowup, the propellant fragments either stop burning or burn very slowly. Such is not the case with liquids.

A few years ago, a noble attempt was made to end the solid-liquid controversy by combining the two types of propellant. Something like engineering a marriage between members of two feudin' families. The result, known as *hybrid propellants*, did not end the ruckus. Instead, it became a third contender in the field, thereby augmenting the general confusion.

Hybrids may consist of solid fuel and liquid oxidizer, or liquid fuel and solid oxidizer. Their proponents claim that hybrids possess all of the advantages of both liquids and solids, with none of the disadvantages. Their opponents claim that the opposite is true. As is usually the case in such situations, the truth lies somewhere between the two extremes. Hybrids *do* have certain advantages over both liquids and solids, but there are still some rather hairy problems to be solved. One of the tougher ones is not strictly a propellant problem.

Some hybrid combinations are capable of producing higher flame temperatures than either solids or liquids—a fact that is often referred to as one of their important advantages. The claim is legitimate, theoretically, in that higher temperature results in higher performance. The clod in the churn, however, is that chamber and nozzle materials haven't yet been developed that are sufficiently refractory to withstand temperatures as high as those the hybrids are capable of producing.

At this point, it would probably be a good idea to step back and take a good look at propellants in general. Just what are the characteristics of a formulation or combination that determine whether it will be a good rocket propellant

First of all, the propellant must contain a goodly amount of energy per pound. A common misconception is that rocket propellants contain fantastic amounts of energy. You hear of "high-energy" propellants that produce temperatures of thousands of degrees, and you see movies—with entirely inadequate sound effects—of the raging inferno that comes thundering out of a rocket's nozzle. Well, there *is* a lot of energy there, but it takes a lot of propellant to produce it, and for only a very short time.

Actually, the energy content of rocket propellants currently in use is surprisingly low. Higher-energy propellants are under development, but it is highly unlikely that any chemical rocket propellant can have a heat of combustion as high as those of some of our everyday, old-fashioned fuels. This is so because the heat of combustion is given as calories per gram, or BTU's per pound, and rocket propellant combinations include the weight of the oxidizer as well as that of the fuel.

Here is a for instance. Hydrogen has a heat of combustion of about 62,000 BTU per pound: i.e., if a pound of hydrogen is burned in air, and the combustion is complete, it will release 62,000 BTU's of heat. In the process of burning, it will combine with eight pounds of oxygen. Suppose, now, that we are using liquid hydrogen and liquid oxygen as our propellant combination. For each pound of hydrogen, our rocket must carry along eight pounds of oxygen. So, for every nine pounds of the propellant combination, we get 62,000 BTU's, giving a heat of combustion *for the propellant* of 62,000/9, or roughly 6,900 BTU per pound! Compare this with the heats of combustion of wood (9,000), coal (14,000), and crude oil (20,000). And remember that the hydrogen-oxygen combination is one of the most "energetic" of the propellant combinations. In actual practice, the figure of 6,900 BTU per pound is somewhat high for the hydrogen-oxygen combination because, for ballistic reasons, the ideal 1:8 proportion—stoichiometric ratio—of hydrogen to oxygen is not used.

In solid-propellant formulations, both the fuel and oxidizer components are usually chemical compounds that must be decomposed, with attendant loss of energy, before they can take part in the oxidation reaction. Also, some of the com-

Fig. 5: A Minuteman booster is test-fired. Solid-propellant motors, such as this, produce higher thrust than liquid-propellant engines of comparable size and weight, but their firing time is limited by the ability of their uncooled nozzles to withstand erosion by hot, high-velocity gases and solid particles in the exhaust stream.

Photo Courtesy of Thiokol Chemical Corporation.

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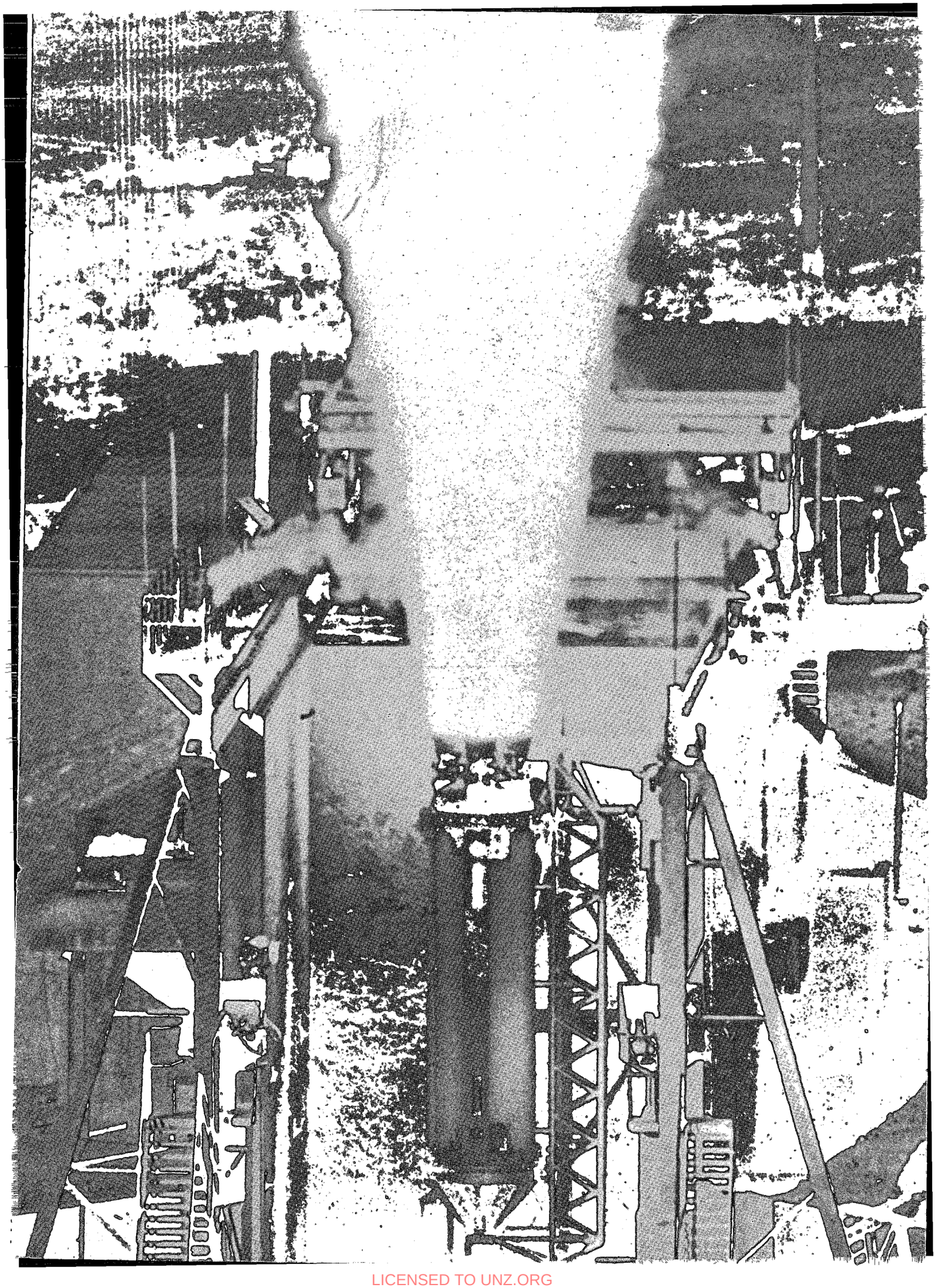

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pounds may include dead weight in the form of atoms that do not take part in the combustion, and most additives for controlling physical properties, chemical stability, and burning characteristics do not contribute much heat, if any. In view of the foregoing, it should not be surprising that the heat content of solid propellants is quite low. Most of them produce somewhere between 1,400 and 2,100 BTU per pound.

Inasmuch as rocket propulsion is accomplished by expelling *gas* through a nozzle at high velocity, one of the necessary attributes of a practical propellant is the capability of producing large quantities of gas at a high temperature. (The higher the temperature, the higher the efficiency.) Obviously, a propellant that would burn without producing any gaseous combustion products at all would produce no thrust whatsoever, regardless of the amount of heat released.

The molecular weight of the combustion gas is also an important factor in the ability of the propellant to produce a high exhaust velocity and, consequently, a high thrust. The thrust varies inversely as the square root of the molecular weight of the exhaust gas. For example, by reducing the molecular weight by a factor of four, we get twice as much thrust. The advantage of lower molecular weight accounts, to a great extent, for the popularity of propellants containing high percentages of hydrogen in their component compounds.

To increase thrust, fuel-oxidizer ratios other than stoichiometric are commonly used to reduce the average molecular weight of the combustion products. For example, in the case of the hydrogen-oxygen combination, the H-O ratio is increased because the unburned hydrogen lowers the average molecular weight of the exhaust. The resulting loss of energy is more than compensated for, at optimum ratio, by the increase in thrust.

Propellant density is an important consideration. The lower the density, the larger will be the volume required to contain a given weight of propellant. A larger container, in turn, means greater structural weight —which lowers the rocket's performance. Hence, the higher the propellant density, the better.

The above are not all of the theoretical factors that determine whether a propellant is "good," but they are among the more important ones. There are, of course, practical considerations, also. A propellant should be reasonably safe to handle, both during manufacture and subsequent shipping, loading, et cetera. It is also highly desirable that the propellant be storable: i.e., that it be capable of being stored for reasonable periods without the occurrence of physical or chemical changes that might affect its performance.

Perhaps it is too much to expect that any propellant will ever have *all* of the desirable characteristics mentiond above. At any rate, the ideal propellant has not yet been found.

Propellants are rated on the basis of *specific impulse*. If a thrust of one hundred pounds acts for a period of ten seconds, an *impulse* of 10 X 100 = 1,000 pound-seconds is produced. If, during the ten-second period, five pounds of propellant was consumed, the specific impulse would be 1,000/5, or 200 pound-seconds per pound (200 lb-sec/lb).

If a long family history and noble lineage meant anything, solid propellants would win hands down. The first ancestor of all solid propellants made its debut in China sometime around A.D. 1000. It was, of course, the mixture of sulphur, charcoal, and saltpeter which would undoubtedly have been called gunpowder by its discoverer—except for the fact that guns had not yet been invented. It attracted considerable attention by propelling "fire arrows," and one of its early descendants—Circa A.D. 1500—propelled a Chinese gentleman by the name of Wan-Hoo to his ancestors in what was probably the first attempt at a rocket-propelled aircraft.

More recent members of the family powered the Congreve rockets which, when used by the British against Fort McHenry during the war of 1812, provided inspiration for a line of our National Anthem—"The rockets red glare." From that time until the 1930s—with the exception of brief periods of service during the Mexican and Civil Wars with Hale's "Stickless"—fin-stabilized—military rockets—solid propellants found very little employment in the rocket business, mainly because there was very little rocket business. (It is said that, during the Civil War, the only practical use for rockets was to "spook" the enemy's cavalry horses.) They found occasional jobs harpooning whales, tossing life lines to distressed seamen, entertaining Fourth-of-July crowds, and pushing signal flares short distances into the troposphere, but most of their activities had to do with kicking projectiles out of the barrels of guns of one kind or another, at—what used to be considered—high velocity. (It is difficult to realize that less than a generation ago, a bullet, with its muzzle velocity of only about Mach 2.5, was universally accepted as the symbol of great speed!)

In the meantime, those solid propellants that had been employed in gunnery had undergone a considerable amount of evolution. The ancestral black powder had a lot wrong with it. It was not powerful enough to be either a good propellant or a good explosive, its burning rate was neither predictable nor controllable, and it left a stubborn, corrosive deposit in the barrels and firing chambers of guns in which it was used.

The first real improvement came about as a result of two accidental discoveries, both occurring in 1846. Nitrocellulose was discovered by Schonbein in Switzerland, and an Italian by the name of Sobrero discovered nitroglycerine. Both nitro-

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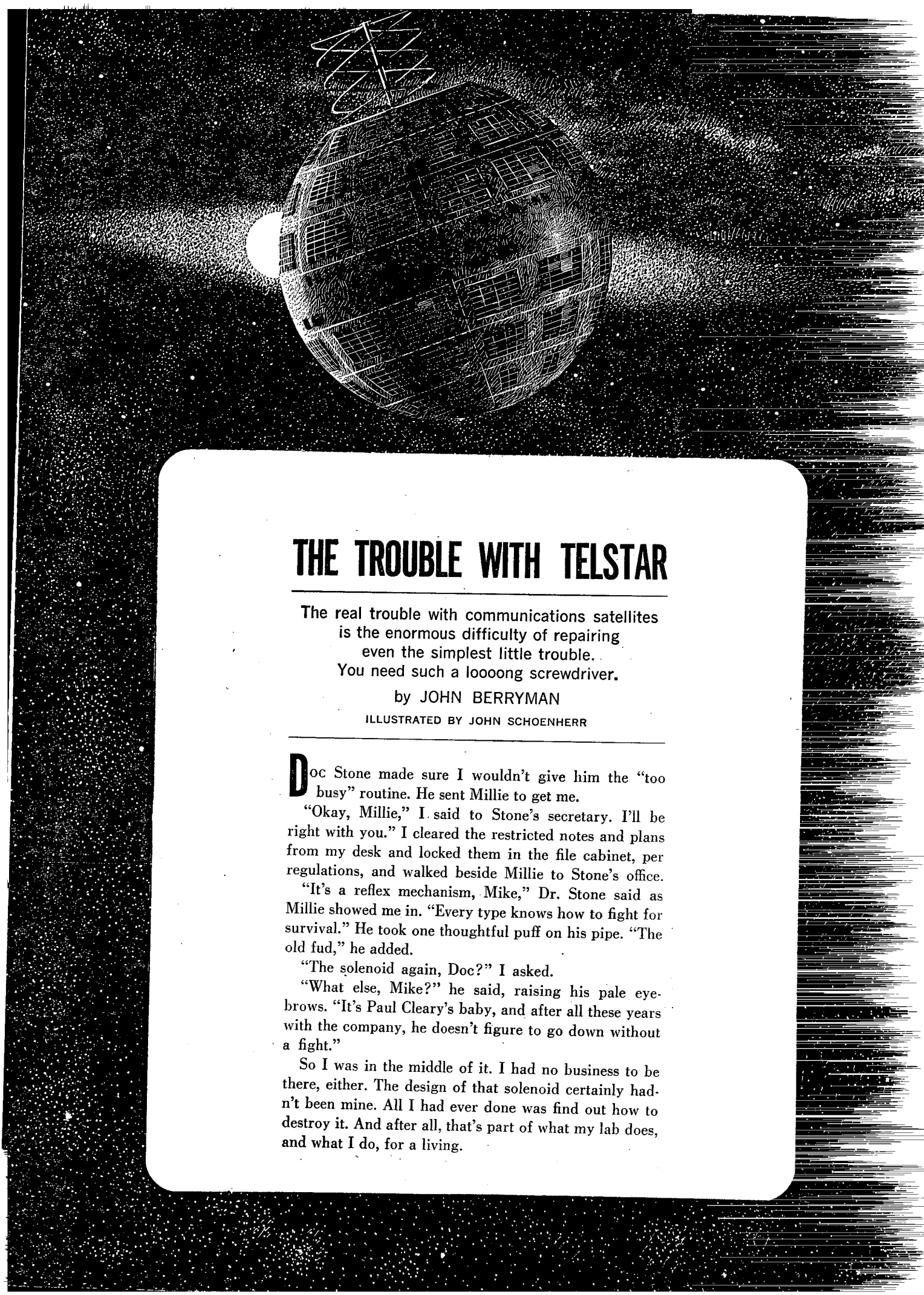

THE TROUBLE WITH TELSTAR

The real trouble with communications satellites is the enormous difficulty of repairing even the simplest little trouble. You need such a loooong screwdriver.

by JOHN BERRYMAN

ILLUSTRATED BY JOHN SCHOENHERR

Doc Stone made sure I wouldn't give him the "too busy" routine. He sent Millie to get me.

"Okay, Millie," I said to Stone's secretary. I'll be right with you." I cleared the restricted notes and plans from my desk and locked them in the file cabinet, per regulations, and walked beside Millie to Stone's office.

"It's a reflex mechanism, Mike," Dr. Stone said as Millie showed me in. "Every type knows how to fight for survival." He took one thoughtful puff on his pipe. "The old fud," he added.

"The solenoid again, Doc?" I asked.

"What else, Mike?" he said, raising his pale eyebrows. "It's Paul Cleary's baby, and after all these years with the company, he doesn't figure to go down without a fight."

So I was in the middle of it. I had no business to be there, either. The design of that solenoid certainly hadn't been mine. All I had ever done was find out how to destroy it. And after all, that's part of what my lab does, and what I do, for a living.

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"Quit staring out the window, Mike," Doc said behind me. "Here, sit down."

I took the chair beside the desk and watched him go through the business of unloading his pipe, taking the carefully air-tight top off the humidor we had machined for him down in the lab, and loading up with the cheapest Burley you can buy. So much for air-tight containers. Doc got it going, which took two wooden matches, because the stuff was wringing wet—again thanks to an air-tight container.

"I just left Cleary's office, Mike," he explained. "He won't admit that there's any significance to the failures you have induced in his solenoid. He insists that your test procedures affected performance more than design did, and he wants to talk with you."

"Great," I said glumly. "Can I count on you to give me a good recommendation for my next employer?"

"Cut it out, Mike," he said, coming as near to a snap as his careful voice could manage. He blew smoke out around the stem of his pipe. I think sometimes it's a part of his act, like the slightly-out-of-press sports jacket and flannel trousers. It says he is a sure enough Ph.D. If you ask me, he's a comer. You can't rate him for lack of brains. He knows an awful lot about solid-state physics, and for a physicist, he sure learned enough about micro-assemblies of electronic components. I guess that's why he was in charge of final assembly of the Telstar satellites for COMCORP.

"Don't worry about what Paul Cleary can do *to* you, Mike," he suggested. "Think a little bit more about what Fred Stone can do *for* you. Cleary is only a year or so from retirement, and you know it."

"He could make that an awful tough year, Doc," I said. "You told me he won't hear of design bugs in that solenoid. He'll insist something went wrong in assembly."

Doc Stone smiled thinly at me and brushed at his blond crew cut. "It is a tough spot, Mike," he agreed. "Because I won't hear any talk of faulty assembly. You'll have to choose, I guess. If you think you can make your bed by playing footsie with an old fud who has only a year to go, try it. Just remember that I've got another thirty years to go, and I'll breathe down your neck every minute of them if you let me down!"

"Sure," I said. "When do I see him?"

"Now."

Doc Stone got somebody named Sylvia on the phone and then told me to go right up. After I got there, I had to sit and wait in Cleary's outer office.

I shared it with a small, dark, intense girl named Sylvia Shouff, if you believed the little plastic sign on her desk. There was barely room for it in the welter of paper, files, notebooks, phones, calendars and other junk she had squirreled. She was much too busy banging at a typewriter and handling the phone to pay any attention to me. Her pert, lively manner said she hadn't taken any wooden nickels lately.

But I had. The last series of tests in my lab had put me in the middle of a hell of a scrap. It had all started a couple years back, when the final design had been approved for a whole sky-full of communications satellites. Well, eighteen, to be exact. One of the parts in the design had been a solenoid, part No. M1537, which handled a switching operation too potent for a solid-state switch. That solenoid was one of the few moving parts in the Telstars, and it had been designed for skeighty-eight million cycles before it got sloppy or quit.

In practice, out in space, the switching operation simply hadn't worked. After about a hundred hours of use in Telstar One, it failed. Unfortunately, this had not been discovered until the first six satellites had been launched. Further launchings were postponed while they ran accelerated switching tests on satellites Two through Six out in space. The same kind of failure took place on each bird.

There were two schools of thought on licking the bug. Doc Stone, of course, insisted that solenoid M1537 had failed, which was one possible interpretation of the telemetry. And Paul Cleary, who had been in charge of design, insisted that faulty assembly was to blame. Well, somebody would make up his mind pretty soon, and my evidence would have a lot to do with it. I had done the appraisal tests of the circuit in the test lab once the bug had been detected, and now Cleary was going to smoke it out of me.

"Mr. Seaman," Sylvia Shouff said to me, kind of waking me up. "Mr. Cleary will see you now. Have you ever met?" she added, as I came toward her desk.

I shook my head. "I'm a working stiff," I said. "I never get to meet the brass."

"You are also somewhat insolent," she said tartly. "Better wash out your mouth before you try that on Paul Cleary. He eats wise young laboratory technicians for breakfast."

"Yes, *mam!*" I said, feeling my ears burn. She led me to the door, opened it, and introduced me to Paul Cleary. He lumbered out around his desk and shook my hand with his rather gnarled and boney paw.

"Hello, Seaman. I'm glad to meet you, young man. Come in. We have a lot to talk about," he said.

Considering that Cleary was a wheel, and had thirty years of service with Western Electric behind him, his office wasn't especially large. Maybe that's because Communications Corporation is owned half by the government and half by AT&T The government half makes us watch our pennies.

"Have a seat, Mike," Cleary said, going around to lower himself carefully into a tall swivel chair. He leaned back and rocked slowly, like an old woman on the front porch of a resort hotel. His pipe was still smoking in a rather large ashtray. He picked it up, showing it to be a curve-stemmed old-man's style, and puffed contentedly at it. On him it didn't look like an act.

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"Well," he said, pulling big shaggy eyebrows down so they shaded his pale blue eyes. "You've become something of a celebrity around here, Mike."

This was an unexpected approach. "Nobody told *me*," I complained. "Does this kind of fame show up in the paycheck?"

"Not always," Cleary said, scowling a little. "I just meant that your name gets bandied about. Every time I talk to Fred Stone he says, 'Dr. Seaman says this,' or 'Dr. Seaman says that.' I just had to see what this doctor looked like."

"You can forget the doctor part," I said uncomfortably. I had heard that Cleary was sensitive about having no advanced degree. When he went to work for the Western, college was plenty. You did your post-graduate work on the job. He sure had—and he had a string of patents as long as your arm to prove it.

"That's good," he said. "I'd hate to think I was competing with you in the field of knowledge where you are the world's specialist."

I grinned at him a little sickly. "COMCORP has never made any use of my specialty," I conceded. "You already had about ten guys around here who had learned twice as much as I had simply by doing it every day for a living. They could have written rings around my thesis."

"Sure," he said contentedly, puffing more smoke. "So we made a testing engineer out of you. And you may amount to something, to hear Fred Stone tell it."

"Thanks," I said.

"Now let me hear what you've been doing for Fred," Cleary suggested, in a sort of avuncular tone. "I'd like to measure you myself."

"You mean the tests I ran on the switching gate?" I asked.

"Why, yes, we can start there," he nodded, squinting his blue eyes more and blowing a real screen up between us.

"When Telstar One packed up, they sent me down the whole gate from that sector," I said. "Dr. Stone asked me to run destruct tests on the whole assembly, which I did. The only failures I have induced so far are failures in M1537, the solenoid that all the shouting is about."

"What kind of failures did you get?"

"Armature froze on the field," I said. "I guess the bearings really went. When there was enough load on them, they couldn't maintain concentricity."

"What kind of loads?" he growled, sinking down lower in his chair. He put his elbows on the arms and laced hairy-backed fingers together under his chin.

"I put the whole gate on the centrifuge and swung it up to twelve gees" I said. "Switching was normal there for the twenty thousand cycles I gave the gate. But when I added undamped vibration at twelve thousand to fifteen thousand cycles per second, I could induce failure pretty quickly. Say an hour or so."

"You had to apply the vibration throughout the whole test period to get these failures?"

"Yes, Mr. Cleary."

"Then how do you explain how vibration during no more than six or eight minutes of blast-off and launch could have the same effect on the actual installation on M1537 in a satellite, Mr. Seaman?" Smoke poured from the curve-stem.

"I don't have to explain it," I said, beginning to get a little hot. "All I have done is find a way to make one part quit. I haven't said it did quit in use, or that it could be made to quit in use."

"Then what the hell are you good for?" Cleary growled.

I didn't have any answer for that.

He repeated his question, blue eyes glittering. "I asked you what the hell you were good for, Seaman!" he said, much more loudly.

"For putting in the middle," I snapped back.

"That's how you interpret this affair, then?"

"Yes."

"All right," Cleary said, straightening up. "We'll stop talking about your work as if it were scientific study and talk about it as a play in office politics. Is that what you want?"

"I don't want any part of it," I said, hoping I wasn't plaintive. "I work under orders. The director of assembly asked me to test a part to destruction. I tested it. I'm sorry that it wasn't a soldered joint that failed. It wasn't. It was a solenoid. What has that got to do with me?"

"Nothing, maybe," Cleary conceded, pushing himself up out of his chair. He went to his window to stare out at the parking lot. "You can be a test engineer all your life, if that's what you want."

"It isn't."

"And what do you want, Mike?" he said, turning back to face me.

"Your job," I said. "In time."

He nodded. "Well said," he decided. "But if you want it, you'll have to learn that business is about ninety per cent people and about ten per cent operations. You know, as you have clearly shown, that Fred Stone is pushing to get me out of here a little before my time, and pushing to make sure that he gets this spot, for which there are other claimants of equal rank in the organization. Oh, no," he said, holding up his hand. "Don't tell me that is none of your affair. Right now you are in the unusual position of being able to cast a vote that will decide just how soon Fred Stone can make his move for the top spot. And as long as you sit there and try that smug line of 'I just test 'em and let the chips fall where they may,' you are really siding with Fred Stone. I need something else out of you, and you know it. What's it going to be? Are you a wise enough head at your years to pick a winner in this scrap? And

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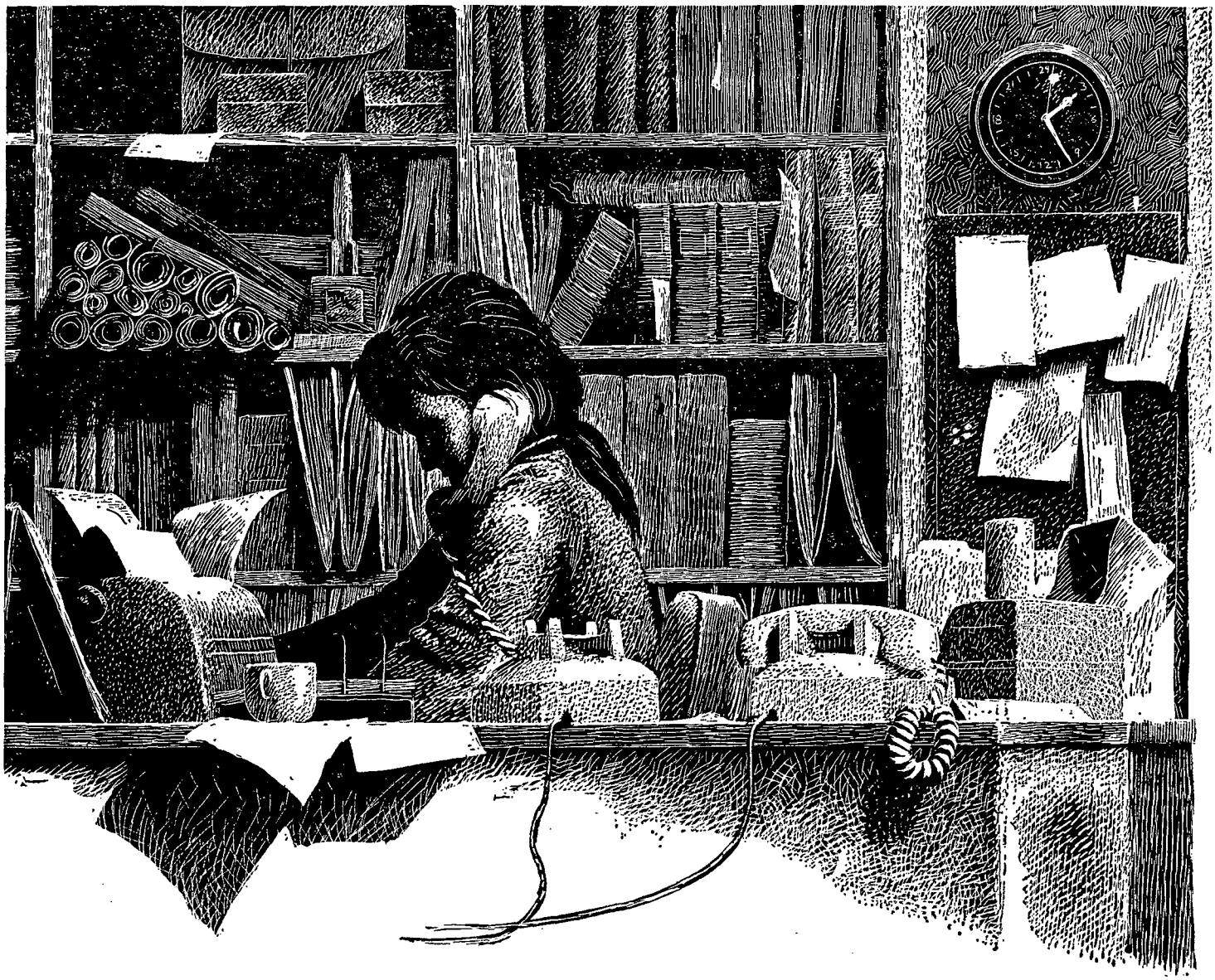

what if it *isn't* Fred? I'll have your hide, young man."

"That's what your snippy little brunette said," I told him. "She told me that you'd eat me for breakfast, and she was right." I got to my feet.

"Where are you going," he growled. He was still standing behind his chair.

"To look for another job, Mr. Cleary. There must be some place where the honest result of a test will be assessed as the honest result of a test rather than a move in a political fight."

"Honest result?" he echoed, and snorted. "*Was* your test honest? What *really* happened out there in space?"

"Nobody asked me," I said hotly. "My assignment was to test that gate until a part failed."

"A dishonest assignment," Cleary said. "Sit down a minute." We both calmed down and took our seats. I got a cigar out of my coat, peeled the wrapper and made counter-smoke. "Here, I'll give you an honest assignment, Seaman. You're a test engineer. Tell me what happened *out there in space*. Why did that switching operation fail?"

"I haven't the faintest idea," I said.

"Then find out!"

I chewed my cigar. "Without duplicating the conditions?" I protested. "And how can we? There's zero gravity—zero pressure—all sorts of things going on out there we can't duplicate in a lab."

"I really don't care how you do it," he said. "But if it were my job I'd just light my pipe and sit here and think for a week or so. Why don't *you* try it?"

I got up again. "Yes, sir," I said. "I suppose it would help to have the original telemetry data so that I could evaluate for myself what went wrong."

"I thought you'd get to that," he said, passing me a fat file-folder. "Here it is." He stood up, too, and led me to the door. "Any other data you might want?" he asked, now a good deal more kindly. His hand was on my elbow.

I looked at him. "How about the phone number of the brunette out there?" I asked without taking the stogey from my teeth.

"Sylvia? That's pretty valuable information," he said,

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beginning to grin in a sleepy old fashion. "But she only dates astronauts. If you haven't made at least three orbits, she won't even have dinner with you."

I stopped at Sylvia's desk with half an idea of asking her for a date. "Well, Dr. Seaman," she demanded as I chewed on my pacifier. "What did you learn?"

I thought about it. "That a lot depends on knowing where to put your feet," I said, puffing smoke. "And my name is Mike."

She sniffed. "If you think Paul Cleary hasn't been around long enough to catch Fred Stone trying to fake him out of position with a meaningless test," she said, "you have another think coming!"

"He'd never have tried it," I told her, "if he'd known Cleary had you to look after him." That got me a much louder sniff and a toss of the dark curly head, which broke up my plans to ask her to dinner.

The telemetry results had been decoded, of course, so that a mere mortal could read them. I didn't have a pipe, which probably meant I'd be a failure as a physicist, so I chewed cigars ragged for about three days and did some serious thinking. When I got a result, I looked up Shouff, Sylvia, Secy./Mgr./Dsgn., in the phone directory, and talked to my favorite brunette.

"Mr. Cleary's office," she said.

"When would he like to see Mike Seaman?" I tried.

"Probably never," she told me. "But I suppose he'll have to. Isn't Fred Stone going to run your errand for you?"

"I'm running Fred Stone's errands, isn't that what you really think, Sylvia?" I asked her.

Sniff! "He can see you at eleven." Click.

Paul Cleary had his coat off and was poring over a large black-on-white schematic when I was shown in by

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sniffin' Sylvia. "Hello, Mike," he growled. "Here, Sylvia. Mike's not supposed to see this stuff. Drag it away, honey. Drag it away!"

With quick motions she rolled up the drawings, snapped a rubber binder around them and went out. Cleary wagged his hairy old paw to the chair beside his desk.

"So you've been thinking?" he asked, reaching for his curve-stemmed pipe.

"How do you know?"

"My spies tell me you haven't been out in the lab since the other day. Certainly you were doing something besides sulk in your office."

"Yes."

"Well, what did you come up with? Why did that switching operation fail out in space."

"I don't know."

His shaggy eyebrows shot up. "You don't know? Is that all COMCORP got for three days' pay?"

"A confession of ignorance is a hell of a lot more revealing than a solid error," I snapped. "The honest answer that I get out of the telemetry data is that something in that gate broke the circuit and the switching operation failed. I think there are about seven thousand components in the gate. I don't know which one failed. A few I can rule out, because they would only cause part of the gate to fail. But a hundred different breaks could account for the data. So I don't know."

He lit his pipe and blew smoke around the curved stem before he made reply. "So we got a philosopher for our money," he said. "A confession of ignorance, eh? What are you going to do about it?"

"You tell me, Mr. Cleary. You're the old head around here."

"So I am," he said evenly. "So I am. Well, my advice to young pups is that they should not be ashamed when they don't know. They should say so. But they should have something else to say along with it."

"For example," I suggested grumpily.

"They should say, 'I don't know, but I know where to find out,' " he said. "Tell me, Dr. Seaman, do you know where to find out?"

He puffed at me for the two or three minutes I thought about it. Really, that's a very long time to think. Most ideas come to you the moment you identify the problem, which is the really hard part of thinking. But this problem took some thought, and I wanted him to think I was thinking.

"Yes," I said at last. "I know where to find out."

"Where?"

"Out in space."

This called for a lot more smoke. "You mean, go out there and look at the satellite, in space?"

"Yes. I can't imagine any other way really to figure it out."

He nodded. "You may be right, Mike. But do you know how much it costs to send a manned satellite aloft?"

"Oh," I agreed. "There are cheaper ways. We can beef up every part in that gate, test it much tougher than we already have, and when we get the gate to where all seven thousand components can stand any imaginable strain, we can rebuild the twelve Telstars we haven't launched yet and be pretty sure they won't have switching failures. But that isn't what you asked me."

"We'd have to fix eighteen of them," he said. "The first six are about sixty per cent useless. They'd have to be replaced."

"I still think you should consider sending a man to examine the Telstars in orbit," I suggested.

"Science demands it, eh " he growled.

"No. I was thinking that perhaps a simple repair could be made in space, and that you wouldn't have to launch six extra birds."

He got out of the chair and went to the clothes tree to put on his coat. The elbows were shiny from leaning on his desk. "It might be cheaper at that," he said. "The first six are launched in only two orbits. Three telstars in each orbit, separated by one hundred and twenty degrees. Two launches of a repair man might do it, with careful handling. Is that what you had in mind?"

"Something like that."

"We'd have to send a pretty rare kind of a repair man, Mike," he said, coming back to sit on the corner of his desk and glower down at me. That was about his kindest expression.

"Yes," I agreed. "You need somebody who can test and diagnose, and then make a repair."

"And who is an astronaut, too," he said. "I wonder if there is such a thing?"

"Make one," I suggested.

He scowled a little more fiercely. "Explain that," he ordered.

"I figure you could take one of our men from my laboratory, who knows how to test the gate, and a man who is handy enough with miniature components to cut out the one that failed and replace it, and teach him how to get around in a spacesuit. That would surer than hell be quicker than taking one of these hot-shot astronauts and teaching him solid-state physics."

"Yes," he agreed, looking down at his fingers. "That was a pretty sneaky way to get out from between Fred Stone and me, young man."

I couldn't resist it: "That's what took most of the three days," I said, just a little too smugly.

"I liked you better in the middle," Cleary grumped. "Well, you have a thought, and it calls for a conference." He took his coat off again, hung it on the clothes tree, came back to his desk and got on the phone.

"Sylvia? Have Fred Stone come up, and you come in with him, eh? That's a dear."

He racked up the instrument and smiled at me as he

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stoked his pipe into more activity. "Relax," he advised me. "It always takes a while to round up Fred Stone."

He wanted no small talk, so I fidgeted in my chair while Cleary rocked gently in his. In about ten minutes, curly-headed Sylvia brought Dr. Stone in with her.

It was, "Hello, Fred," and "Hello, there, Paul," when they came in. Sylvia didn't have anything to say, although she gave me a hot-eyed glance before pulling out the dictation board on Paul Cleary's desk and making herself comfortable with her notebook.

Cleary offered Doc Stone some of his tobacco, which was politely refused. The old man began it:

"Your Dr. Seaman has quite an idea, Fred," he said, in a mild, kindly voice, with a dumb, guileless look on his face.

"Good, Paul," Doc Stone smiled thinly. "I've told you he's a good boy."

"Hm-m-m," said Cleary. "He says his tests can't prove what went wrong with the switching gate on the satellites, and in effect that the telemetry doesn't make it plain whether we have design or assembly trouble."

"Well, *well!*" said Fred Stone. I decided to start shopping for a marker for my grave.

"Yes," Cleary said. "He made quite a suggestion, that we send a man out in space to look over the Telstars and find out what went wrong. Even better, he says it might be possible to make a repair at the same time and get the bird working. You can see the advantages of doing that, the way they are orbiting."

"Yes, indeed," Doc Stone said, looking at me with slitted eyes. "Quite a unique adventure for some technician."

"Just what I was thinking," Cleary said. "The problem resolves into: Who do we send? Now Mike, here, says we should take a man from his lab who knows the bird and its assembly and teach him how to get around in a spacesuit—that, he claims, would be quicker than taking one of these space jockeys and making a technician out of him."

"I think he's right."

"So—there we are. Who do we send?"

"There can hardly be any choice," Dr. Stone said, looking at me with eyes like granite.

"Hardly," Cleary agreed. "The head of the lab is the best man, beyond a doubt."

They were talking about me! Try to get out of taking sides, would I? Cleary wanted me back in the middle. Stone wanted me dead. They were both likely to get their way, unless I told them off.

I opened my mouth. Cleary cleared his throat loudly.

"Oh, Dr. Seaman!" Sylvia cut in, breaking her careful silence. "What a thrilling opportunity for you!"

I gaped at her. Well, Cleary had said it. She only went out with astronauts. She was space-happy.

"There are men in the shop who deserve the chance . . ." I started.

"Nonsense!" she said quickly. "It's your idea, doctor, and you deserve the fame!"

"And the promotion this will undoubtedly earn—if you can bring it off," Cleary added.

"Yes!" Dr. Stone said with relish. He didn't think I could, either. Well, that made three of us, unless Sylvia made four.

"Thank you very much," I started, as a prelude to backing out.

"Good, that's settled," Cleary said. "That's all, Sylvia."

She got up and left. She had done her dirty work. If I hadn't been so sick at my stomach, I would have had to admire really great teamwork.

Stone shook my hand with an evil kind of relish and followed her out.

That left Paul Cleary and me alone. "This is a great thing, young man," he said.

I couldn't stand him any longer. "You are a worm!" I told him.

"You're probably right, Mike," he agreed, without any particular heat. "But a rather just one. I think you'll admit you've been paid off in your own coin. All you had to do was beg off."

"In front of her? You knew I wouldn't."

"I *figured* you wouldn't. That's one of the advantages of being older. You know more about how the young will behave. Come on," he said, getting up to put on his coat again. "We have to see a man."

"One thing," I said, as I got up, "while we're being so just."

"Yes?"

"I had thought of asking your Sylvia for a date. But she was so snippy the other night I decided to forget it. Now, she got me into this, and she'll have to pay and pay! How do I get to her? It'll be quite a while before I'm an astronaut."

He took his pipe from between his teeth. "This calls for the wisdom of a Solomon," he decided. "But you might try oysters."

It was pretty good avice. I hung behind him long enough to tell Sylvia about the Chincoteague oysters they put in the stew at Grand Central Terminal, and got a dinner date. That was all, just the date, because Cleary was itching to take me to see a man.

Politics must be an awfully large part of business. The man we went to see was the government side of COMCORP, and I guess he had had to do as much explaining about Telstar failures to a Senate Committee as Paul Cleary had had to do to the Western. He wanted an out just as bad as Paul did.

There were a good many conferences before a sufficient number of people decided the cheapest way out was to send a man to fix the Telstars that had broken down. The question was whether it was possible.

We went at it from two directions. They got a team

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assigned to figuring out if the Dyna-Soar rocket could be modified to make the three contacts around the orbit, carry two men and enough air and fuel for the job, and at COMCORP we appointed a crew to figure out what it meant to make the repair in orbit.

Cleary put me in charge of our crew. They gave me a full-size Telstar satellite for my lab, and I went to work.

Fancy electronic equipment consists of millions of parts, and Telstar is no exception. One of the bonuses America got from its poor rocket booster performance, as compared with the Russians, was a forced-draft course in miniaturization. Our engineers have learned how to make almost anything about one-tenth the size you'd think it ought to be, and still work. To get all these tiny parts into a total system, they are assembled in racks. In the Telstar each of these long skinny sticks of perforated magnesium alloy is hinged to the main framework so that it can be swung out for testing or for replacement of parts, which is why the engineers call each component a "gate."

I spent several weeks learning how to take each suspected component out of the gate. Most of the time I needed a screwdriver. Sometimes I had to drill out a soft aluminum rivet. The hard part was that some of the components were so deep inside, even with a couple gates swung out of the way, that I needed all kinds of extension tools.

Of course, I had to visualize what it would be like doing all this out in space. I'd be in a spacesuit, wearing thick gloves, and when I removed a screw that would have looked good in a Swiss watch, there'd be no work bench on which to place it while I took out the next one. Worse yet, I would have to put it back in.

The longer I worked with the parts, the harder it looked. There wouldn't be a prayer of just turning the parts loose in space. In theory they'd follow along in orbit. In practice you can't bring your hand to a halt and release a tiny part without imparting a small proper motion to it. And even worse, you couldn't handle the little wretches when you tried to put them back in. With a solid floor to lie on, with gravity to give things a position orientation, I kept losing tiny screws. Magnets didn't help, because the screws were nonmagnetic for what seemed pretty good reasons. Some were made of dural for lightness. Some were silicon bronze. None of them was steel.

That put us back in the lab to find out what would happen if we used steel screws. The answer was, surprisingly, nothing important. So there was one solid achievement. I had a few thousand of each of the thirty-four different sizes of fasteners machined from steel, and magnetized a fly-tier's tweezers. The result was that I could get screws back into their holes without dropping them, especially when I put little pads of Alnico on the point of each tweezer to give me a really potent magnet. Then we had to cook up an offset screwdriver with a ratchet that would let me reach in about a yard and still run a number 0-80 machine screw up tight. That called for a kind of torque-limit clutch and other snivies.

It was the fanciest and most expensive screwdriver you ever saw. The handle was a good two feet long. The problem then became that of seeing what you were doing, and one of the boys faked up a kind of binocular jeweler's loupe with long focus, so that I could lie back a yard from the screw and focus on it with about ten diameters magnification. The trouble was that the long focal length gave a field of vision about six times the diameter of the screw-head, which meant that every time my heart beat my head moved enough to throw the field of vision off the work.

By that time I was working in a simulated spacesuit—the actual number was still being made to fit an accurate plaster cast of my body. So the boys figured out a clamp that would hold my helmet firmly to the gate, and a chin rack inside the helmet against which I could press and hold my head steady enough to keep my binoculars focused where they had to be focused. At a certain point I went back to Paul Cleary and said I thought I could make the necessary tests, dismount what I had to dismount, and replace any affected part.

"All worked out, eh?" he said, reaching for his pipe.

"Not by a county mile, Mr. Cleary. But I know what the problems are, and the shop can figure out sensible answers. Some of the hardest parts turned out to be the easiest."

"Name any three," he suggested.

"Well, the screws. As I take them out, I'll discard them into space. I have to use magnetic screws on reassembly, so there is no point saving what I take out. Doug Folley has doped out something like a motorman's change-dispenser that will dispense one screw at a time into my tweezers, and I'll carry a supply of all thirty-four kinds at my waist."

"That's one," he counted on a hairy forefinger.

"We can use something like a double-faced pressure-sensitive tape to hold other parts," I said. "We'll draw a diagram on it, stick it to some unopened part of the satellite near where I'm working, and as I pull pieces out, I'll just press them against the other sticky face, in the correct place in the diagram, and they'll be there to pull loose when I want them."

"At absolute zero?" he scoffed. "That sticky face will be hard as glass."

"We'll face the bird around to the sun," I said. "And warm it up. If we have to, we'll put wiring in the tape, connect it to Telstar's battery supply, and keep it warm."

"Might work," he grumped. "That's two. How about the spacesuit part?"

That had been tougher. Some forty or fifty men had made the ride into space and back from Cape Canaveral by this time, and there had been rendezvous in space in preparation for flights to the moon. But so far no one had done any free maneuvering in space in a suit.

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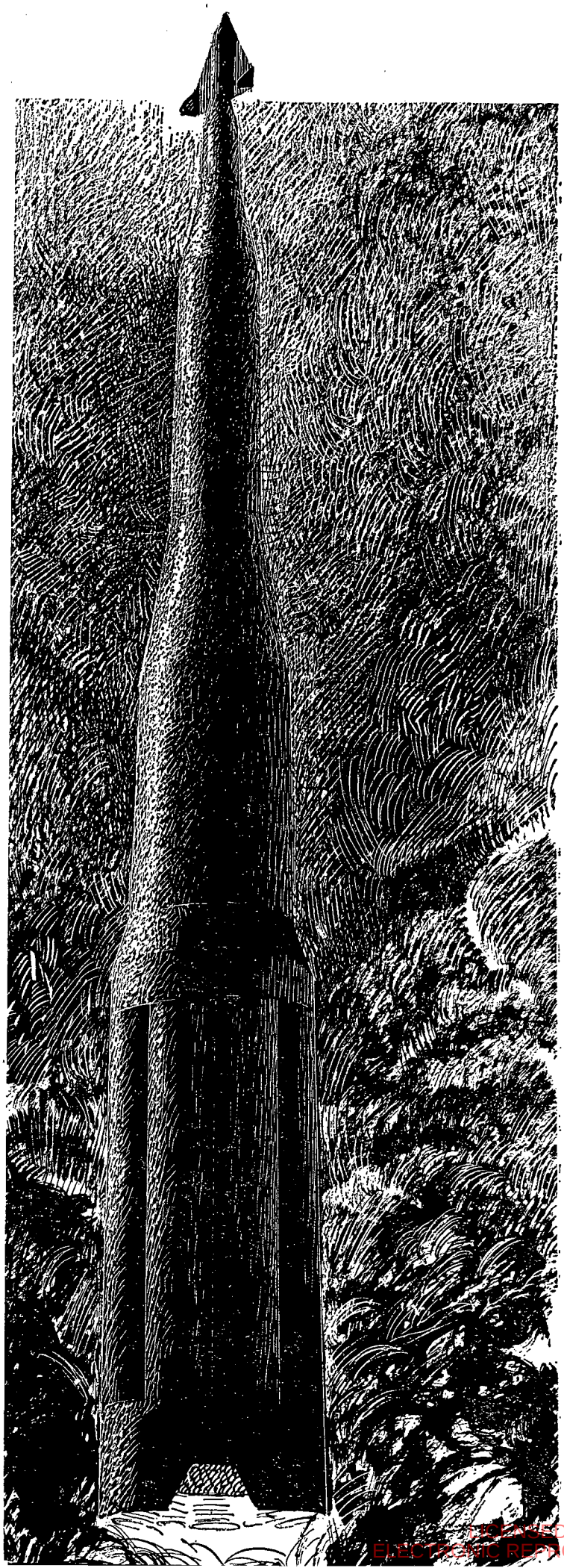

They had put me in a swimming pool in a concentrated salt solution that gave me just zero buoyancy, and I had practiced a kind of skin-diving in a spacesuit. The problem was one of mobility, and the one thing we could not reproduce, of course, was frictionless motion. No matter how I moved, the viscosity of the solution quickly slowed me down. Out in space I'd have to learn on the first try how to get around where every force imparted a motion that would continue indefinitely until an equal and opposite force had been applied.

The force part had been worked out in theory long before. To my spacesuit they had fixed two tiny rockets. One aimed out from the small of my back, the other straight out from my belly. Two pressurized containers contained hydazine and nitric acid, which could be released in tiny streams into peanut rocket chambers by a single valve-release. They were self-igniting, and spurted out a needle-fine jet of fire that imparted a few dynes of force as long as the valve was held open. It only had two positions—full open, or closed, so that navigation would consist of triggering the valve briefly open until a little push had been imparted, and drifting until you triggered the opposite rocket for braking.

The airtanks on my back were right off a scuba outfit.

Really, they spent more time on the gloves than anything else. At first we thought of the problem as a heat problem, but it was tougher than that. Heat loss was not much, out there in a vacuum, and they made arrangements to warm the handles of my tools so that I wouldn't bleed heat through my gloves to them and thus freeze my fingers. No, the problem was to get a glove that stood up to a pressure difference of three or four pounds per square inch and could still be flexed with any accuracy by my fingers. We could make a glove that was pretty thin, but it stiffened out under pressure and made delicate work really tough. It was a lot like trying to do brain surgery in mittens.

They eventually gave me a porous glove that leaked air when you flexed your fingers. Air, they said, could always be gotten from the Dyna-Soar rocket that would be hanging close at hand in space. Well, we hoped it would work. I could do pretty fair work with the leaky gloves, and all we could hope was that the vapor would be dry enough as it seeped out through the gloves to prevent formation of a foggy cloud all around me, or the formation of frost on the gloves. That we could not test under any conditions easy to simulate.

Each team spent ninety days. They tell me that's right quick work for pointing up a launch. But at the end of three months I had assembled enough stuff to do the job, and still well within the weight limit they had to set. I wasn't a walking machine shop, but there was a lot I could do if I had to.

Ninety days had been enough for several dates with Sylvia. Out of the office she wasn't quite the protective harpy about Paul Cleary that she had been in the office,

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although the thought was never far from her mind.

We spent my final night in New York before leaving for the Cape at Sweets, a real old fashioned seafood house down on Fulton street. After the obligatory oysters, we had broiled bluefish, and otherwise lived it up. They serve a good piece of apple pie, and we had that with our coffee.

"Are you scared?" Sylvia asked me.

"Of what?" I lied innocently.

"Of being out in space—just floating around?"

"Yes," I told her honestly. "I'm scared to death. What if I have a queasy stomach? They say a good half of the men who have been in orbit have chucked up or got tend dizzy or something. What if they go to all this trouble and I get spacesick?"

"What if you drift away and can't get back?" she said. "It isn't like swimming back to shore."

"There's always a way," I said, my stomach tightening as I thought of what she said.

That was the night she kissed me good night. It wasn't much of a kiss, because we were standing in the lobby of her apartment house, and she wasn't going to invite me up, because she never did. But she said: "Hurry back."

"Just you know it, Shouff," I said, bitter inside.

I'd have been a lot more bitter if I had known what was in store for me at the Cape. COMCORP flew me down in one of our private prop-jets, with only Paul Cleary for company. He introduced me to the brass, and we sat through a couple conferences while the idea was spelled out to a group of sure-enough spacemen. Then they turned that mob loose on me.

I was emotionally unprepared. First off, Cleary and Fred had been building me up all through the three months, and I had actually gotten to the point where I thought I knew what I was doing. These space-jockeys spent most of their time deflating my ego.

My tormentor-in-chief was a wise punk from Brooklyn named Sid Stein. "How have you made out in your centrifuge tests?" he asked me at breakfast the first morning after I had reached the Cape.

"I have never done any of that stuff, Mr. Stein," I said.

"Well, how many gees can you pull?"

I shrugged. "Same as you, I suppose. How many is that?"

"Brot*her!*"

The space medic wasn't any better. The mission chief insisted that it wasn't safe to put anybody in a satellite who couldn't pass the physical. I guess you know that about one man in a thousand can qualify. This was supposed to wash me out.

"Remarkable shape." The space medic kept saying. "You must take considerable exercise, doctor."

"Oh, no," I said. "Just jog a mile or so before breakfast. Nothing spectacular."

"No other formal activity?"

"Well," I snarled, "just swimming, fencing and weight lifting. I've given up the boxing and handball."

"Kept in excellent shape, nevertheless," he said. "You'll be a disappointment to them."

"Look," Stein said to me after a week of tests and countertests. "Don't be deceived by these tests. All they show is that your heart is still beating. The big thing is emotional. Doc, I think you should reconsider this idea of flopping around out there in the void. We've got experienced men here, and none of them is ready to try it."

"Fools rush in, eh, Mr. Stein "

"Precisely."

In the meantime I got a daily phone call from Paul Cleary. That I could have snarled off, but Sylvia always came on the line first, and there was a minute or so of chit-chat before she cut her boss in on the line. I'm sure she listened to all the calls. But her first words were deadly. For example:

"Mike! Hi, Mike. Mr. Cleary wants to see how you're doing."

"Good. Put him on."

"In a minute. I think it's so wonderful you passed the final physical, Mike. You're really so deceptive. I never had imagined you had such a steely physique."

"Clean living," I said. "No girls."

"There'd better not be!"

"Don't worry. How could I get to see any girls down here? Every time I look away from my work all I can see is Bikini swim suits."

"Cut that out!" she snickered, and put Cleary on the line.

There came a final day when the mission chief called me in to his office.

"Come in, Mike. Come in," he said shortly. "Sit down." He leaned back against his desk and started talking to me, like they say, straight from the shoulder:

"I'll give it to you straight, Mike. We've tried every legal way to wash you out of this mission. There isn't a one of us here at the Cape that wants any part of taking an armchair theorist and slapping him into space—into the kind of a mission you've cooked up. Somebody's going to get hurt out there, because you aren't fit for the job. Now, physically, yes, you have the capacity. But emotionally and environmentally, you simply don't add up. You're looking at this thing as an extension of your laboratory, and instead it is an enormous physical and mental hazard that you are undertaking. This country has never lost a man in space—and you'll be the cause of our first casualty, as well as being one yourself. I'm asking you man to man to disqualify yourself."

"And put an end to this mission?"

"We'll train one of our men," he said.

"In two or three years your best man might be barely capable," I said. "I don't think COMCORP is prepared to waste that much time. After all," I said ingratiatingly,

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"all you have to do is refuse the mission. Say I'm a built-in hazard and let it go at that." I grinned at him. I was learning from Paul Cleary. I *figured* how space-jockeys would react to that.

He told me: "Do you think any of these men would admit they are not up to a mission a mere technician is ready to try? No! I can't get them to beg off, either!"

"When do we go?" I asked.

Sid Stein was assigned as my pilot. He had made the trip into orbit and back four times with the Dyna-Soar rocket, and was considered the best risk to get me there and get me back. He was also the least convinced I had any right to sit beside him in the cabin.

His final briefing was a beaut: "This is a spaceship, doctor," he said frigidly. "And I want you to remember the 'ship' part of it. I'm in command, and my every word, my every *belch*, has got to be law. Do you understand that? This is *my* mission, and I'll tell you where to put your feet."

"Sure," I said. "Who wants it?"

"Can't figure out why you do!"

"I'm just paying somebody back," I said. "Is it tomorrow?"

The start was a drag. Eighteen hours before blast-off Sid and I went into a tank so that we would get rid of our nitrogen. We breathed the standard helium-oxygen mix at normal pressure until about four hours before H-hour. They wouldn't even let me smoke. Then we suited up and were lifted by a crane and stuck in the control room of *Nelly Bly*, as I had named our Dyna-Soar rocket-glider. The hatch stayed open, but we were buttoned up tight in our suits. They had a couple of mods that were supposed to fit them better for the mission. Instead of the usual metal helmet with face plate, we had full-vision bubble helmets of clear plastic. The necks were large enough so that we could, in theory, drag our arms out of our suits and clean the inside of the bubbles. That was in case I sicked up out in space, which all experience said was a real enough hazard. They figured that filling me full of motion sickness pills was partial prevention.

These space-jockeys have their own vocabulary, and their own oh, so cool way of playing it during the countdown. I'm pretty familiar with complex components, but they were checking off equipment I never heard of. We had gyros—hell, our *gyros* had gyros. And we had tanks, and pressures and temperatures and voltages and who-stuck-John. It was all very impressive.

There were suited men up on the gantry unplugging our air feed and closing our hatch. Sid was straining up from where he lay on his back to dog it down tight.

"Roger," Sid was saying to somebody, as he had been all morning.

The white vapor from our umbilical stopped, which let me know our tanks had been topped off and sealed, and that we were about to blast off.

"This is it, Seaman," Sid Stein said. "Now for Pete's sake don't move, don't speak, just lie there. I've got the con."

That was a bunch of baloney. He really had nothing to do until we were in orbit. The delicate accelerometers and inertial guidance components did all the piloting until the second stage kicked us loose. But I kept my mouth shut. He'd have some work to do before the ride was over, and I might need him.

When the lift-off came, it was gentle as a dove's wing. But as we burned off fuel, the twenty-million pound thrust of our Apollo booster began to tell, and my vision started to go black. The gee-meter said we were pulling about ten gees when I could no longer read it, and I learned later we peaked out at eleven gees in the final seconds before first-stage burn-out. I didn't like it a little bit.

The liquid hydrogen second stage kicked in like a hopped up mule, and we pulled ten gees, right at the limit of my vision, for its whole four minutes of burning. My earphones were talking now as Sid gave it the A-OK and Roger bit all the way. This was the stuff, kid!

Our Dyna-Soar had been modified to some degree for this mission. It's essentially a big delta-winged glider with a squarish fuselage in the center. The mods had consisted of tying a third rocket stage out behind, so that Sid could move us around the orbit from one Telstar to the next if my work on the first one proved out. The retro-rockets had several times their normal complement of fuel, so that he could stop after he got started. The same was true of our steering jets.

The ship was not pressurized on the lift off. Cabin pressure fell rather quickly, as we could feel from the inflation of our suits, to their three and a half-pound pressure. No bends for either of us, because of the helium substitution for nitrogen. Because there were two of us, we could chuck and unchuck airtanks for each other as we needed fresh supplies. We had enough air and water for forty-eight hours. Together with our low-residue diet for the final week, they figured we could sweat it out in our suits for two days. We had suit radios, of course, and could talk with each other for a distance of a mile or so.

Burnout of the second stage came suddenly, and we heaved slightly against out belts as the springs in our seats pushed back out. And then I got my first taste of free fall. Each veteran astronaut I had talked to at the Cape had a different way of trying to scare me with the idea of falling endlessly, and each had different ideas about how to lick it. In spite of all the talk, I grabbed the arms of my seat to keep from falling. I turned my head and in the glow from our instruments could see Sid sneering across at me through his transparent bubble helmet.

"How you like them apples?" his voice came from my earphone.

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"That first step is a killer, Sid," I said, trying to sound chipper. I felt horrible.

"Let me know when you've had enough," he suggested. "I've got things to do."

I knew he did. We had dry-run it a hundred times. If we had been inserted correctly in orbit, the *Nelly Bly* was right in the path that three of the Telstars were now following, and catching up with Number One at several hundred miles an hour. On the ground, radars all around the world were taking fixes on us, and Sid was talking shop over his long-range radio with the radar crews.

By the time my stomach had made up its mind that it would stick with me, he had a report.

"It could be worse," he said. "We've got a lot more velocity than I'd like, but we're on course. Our orbit would differ quite some, Seaman. Because of this speed we'd be somewhat more eccentric—maybe swing out a hundred miles beyond the birds we're chasing. Are you making it?"

"Easy, Sid. Do we slow down yet?"

"I'll fire the retros and retard us to the speed of what we're chasing," he said. "That will equalize our orbits very nearly. Get busy on that scope if you're up to it. I'll compute my retro."

They had made an amateur radar operator out of me, because it was easy to do, and gave Sid more time for actual rocket valving. My belt cut me hard as he braked for several seconds.

"There," Sid's voice said in my ear. "We should still be catching up about fifty miles an hour. Let's not ram that thing. See any blip?"

"Not yet. How close are we supposed to be?"

He lit the cabin light and tapped at the calculator that he swung out from its rack. "Still got a hundred miles to go, I'd judge." He moved awkwardly in his suit to finger a switch on his neck and I heard him speaking to the ground again, and heard in my earphones the answer that came up from Woomera. We had eighty miles to go, and were now a little below the orbit of the bird we were chasing.

"Can't have both ends of the stick, Mike," Sid explained, calling me by name for the first time. "As soon as we slowed down we had to drop lower." He fooled around with the steering jets, which were hydrazine-nitric acid rockets much like the tiny motors on my suit, and re-oriented *Nelly Bly*. A little burst from the nose, and I got my first blip.

"There!" I said, putting a finger on the PPI. "Turn out the light, Sid, so I can see the 'scope'."

He switched off the cabin light and followed my directions with tiny shoves, sometimes from the rockets, sometimes from the steering jets, while I conned us closer.

Our radar would only read within about half a mile. When we got that close I got the searchlight going and took my first real look through the forward port out into space.

It's black. Nothing—nothing you have ever seen will persuade you how dark it is out there. That was my first big shock. Oh, I had practiced in the dark, with only my helmet light to guide my tests and assemblies, but this was a different kind of dark. Our light had no visible beam—you couldn't even tell it was working. At first I had the idea we'd see the satellite occulting some stars, but a little mental arithmetic told me that an object six or eight feet in section would not subtend much of an angle of vision at half a mile.

We had chosen, I decided, much too narrow a beam of light for the searchlight, but just at that moment I got a flash from out in space, and worked the light back on to our objective.

"Got it," I said.

"Yoicks!" Sid said, and went back to the fine controls. After a long time, and lots of patience, we were hanging about fifty feet out from our bird. We were farther out in space so that the dark bulk of the satellite was silhouetted against the crescent light of Earth. I turned off the spot and switched on the floodlight.

"Here goes nothing, Sid," I said, and undid the dogs that held the canopy above our heads.

My earphone spoke to me: "This is Cleary. Do you read me, Mike?"

I fumbled around to find the right jack and plugged myself into the radio. "Yes, Paul. Loud and clear."

"Watch yourself. Think first. You've got all the time in the world."

"Sure."

"Sylvia would miss you," he added.

I hoped he was right.

Clinging carefully to the handholds that had been specially provided on the outside of *Nelly Bly*, I clambered through the hatch and hung in the darkness, looking down at South America. The world was turning visibly under me, although I knew that in fact we were skimming rapidly about three thousand miles over its surface. I got myself lined up nice and straight with the bird and did my first bit of non-thinking. I pushed off good and proper with my feet, the way you'd dive into a swimming pool. It was a fool stunt for my first act. I was doing a good five or six feet a second. You may not think that is very fast, but before I could gulp twice I had zipped past that bird and was headed for Buenos Aires.

I know I screamed. That was the first time I realized I really was falling. Earth looked awfully close, and seemed to be rushing up to meet me.

My orientation was all wrong for stopping. By diving head first I had neither my back nor my belly rocket lined up to stop me.

My training failed completely. I tried to squirm straight, and by proper swinging of my arms out to full

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length, and kicking the same way with my feet, I got turned around to where my belly was facing the floodlight on *Nelly Bly*. That's not how I was supposed to do it.

The glider had disappeared—all I could see was the floodlight. It was still by far the brightest thing in the sky, but if I drifted much longer, I would have to use radio direction-finding to get back. I triggered the motor on my back and felt its gentle push against my spine.

"Sid!" I called.

"Roger, Mike!"

"Light the tip lights. I've got to get a fix on my velocity. I went way past and I'm trying to get back."

Two new stars winked into being, on either side of the floodlight. This had been some bright guy's idea, and it was paying off. I kept watching the apparent distance between them shrink as I continued my trip toward Earth. Memory and a little calculating told me that my acceleration of three inches per second per second would take twenty seconds of blast to slow me to a stop. I counted them off, aloud: "Mississippi one, Mississippi two, Mississippi three," as I had been taught to measure seconds. When I got to Mississippi twenty my visual measurement said I was about stationary with regard to *Nelly Bly*.

I used a little more blast and let a couple minutes go by while I drifted closer to the Telstar. I started squirming again, until I remembered to use the deflection plate they had given me to hold in my belly blast, and that got me lined up. But finally I was within touching distance of the bird, which was rotating with a certain slow majesty on its long axis.

The leisurely spin was there to make sure one side didn't face the sun too long and heat up. My plan called for stopping the bird's spin so that I could get reasonable solar heating of the part I was working on. The trouble was there was nothing to grab as the satellite turned. But we had worked on that part, too, and I went into my act of backing off the right distance, accelerating with my back rocket until I drifted close by the bird at its translational speed. I got one end of my sticky webbing stuck to it by pressure and decelerated so that the bird turned under me while I paid off the web. In a moment I had it girdled, and snapped the nifty sort of buckle they had made for me. Then drawing the webbing tight was no trouble, and I was spinning with the bird. My added weight slowed its spin down some.

Next came the trick of getting some special equipment loose from my right leg. This was a little rocket cannister which had just enough poof, the slide-rule boys had said, to stop the rotation of the bird. I fastened the canister to the webbing, pushed softly with one finger to get me a few feet away, and drifted while waiting for the delayed fuse to fire the antispin rocket. It lanced out a flame for a few seconds, and sputtered dead. The bird hung virtually motionless beneath me—or above me—or beside me—or whatever you want to call it when there is no up or down.

Our light was dimming as we passed the terminator and pulled over Earth's dark side. The sun was still visible, however, although soon to be eclipsed by Earth. I jetted softly back to the bird and lit my helmet light. I had to find the right face of the twelve-sided thing so that I could open the right gate. The markings were there. They were just hard to read from inside a helmet. Then the sun was eclipsed, and my headlamp gave me the kind of light I was used to working with. The sector I wanted was on the satellite's dark side. I had to clamp on to the girdle and jet quite a while to turn it halfway round, and then decelerate just as long to bring it to a stop. I fooled around several minutes getting the sector to face where the sun would soon rise.

My earphone spoke.

"Mike!"

"Roger, Sid. What's up."

"Take it easy on your steering fuel. You're getting low."

"Roger."

I had to wait for the sun before I could start work. When it came up, heating seemed quick. First a test with a thermocouple showed that Telstar's surface was warming nicely and would soon support the pressure-sensitive mat I was going to stick to some of her solar generators. When the 'couple said Telstar had reached zero centigrade, I pulled the mat loose from where it was stuck to my left leg and plastered it above the gate I was going to open. I say above, because it was closer to one pole —the "North" pole of the satellite—than the gate.

It was time to go to work on my first screw. And there I got my next lesson. It was a real big screw, as they go, a 4-40 flat head machine screw with a length of about three-quarters of an inch. I would have to give it thirty turns to back it out. I never gave it the first turn. The head snapped off as soon as I applied a few inch-pounds of torque.

Yes, the surface had heated up nicely, but the shank of the screw was about two hundred below zero centigrade, and far brittler than glass.

I cussed some and reported to Sid what had happened.

"Have to drill it out," I said.

My drill was a cutie. It was a modified dentists' drill, the kind that's run by a little air turbine at about two hundred thousand r.p.m.'s. I really mean that. They turn like mad.

I'd been taught to use it with care. When a dentist drills your teeth, he blows olive oil and water through the turbine, and the mixture cools the tooth—and the drill—while the cutting is going on. We couldn't afford any cloud of vapor—or the shorting out that ice would cause—so I had only the pressurized mixture of oxygen and helium in the tanks on my back to run the drill. And that meant light and intermittent pressures

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on the number 43 wire gauge drill—the one that's the right size to drill out a 4-40. It took me about fifteen minutes and I was down to my last number 43 drill bit when she broke free.

From then on I had to heat each screw before I went to work on it. I had something like a soldering iron that I could press against the screw-head. Heat would flow through the highly conductive alloy and make it less brittle. I flicked each screw I removed out into space and at last carefully hinged the gate wide open.

The gate was the length of the sector—about two feet. It was four inches wide and about an inch thick and had parts strung along it like kernels on an ear of corn.

At this stage I readjusted the position of my webbing girdle until I could clamp my head in position and begin the testing. It was slow work. The first sad thing was to learn that the solenoid M1537 was as good as new. When I put enough voltage across its terminals, the actuator clicked down through the core.

I swore a blue streak.

"What is it Mike?" Sid's voice came in my ear.

"Trouble," I said. "What did we expect?"

"Roger," he said in that toneless unexcited astronauts' voice. "Return to ship, Mike."

"Not now," I said. "I've just got the oyster opened."

His voice cut like my drill-bit. "I ordered you to return to ship. Your air supply is about shot."

"I haven't been out that long," I protested, not feeling too sure about the lapse of time.

"Your drill chewed it up pretty fast. Quit talking and start moving."

I was thankful for the experience of moving in close to the bird. The same tricks worked much more smoothly as I used my deflection plate in front of my belly blast to turn me to face the floodlight, and then followed up with a light shove or two in the spine to start me drifting toward *Nelly Bly*. There didn't seem any rush, and I drifted slowly over, using only a couple triggered bursts of deceleration to slow me down as I approached the open hatch.

Inside we went through the drill. My ears popped a little as Sid unchucked my spent tanks, and popped again as the new ones came on with a hiss.

"Take it easy on that steering fuel, Mike," he said again. "You're getting awfully low."

"Sure," I said and let myself drift out the hatch. I had enough sense to twist so that my back jet wouldn't hit the ship. Then I took a zig-zag course through the darkness to my bird, got oriented at the open gate and went back to work. Before I could get started, my earphones spoke.

"Mike, Cleary here."

"Roger, Paul. What is it?"

"Have you gotten to that solenoid yet?"

"Yes."

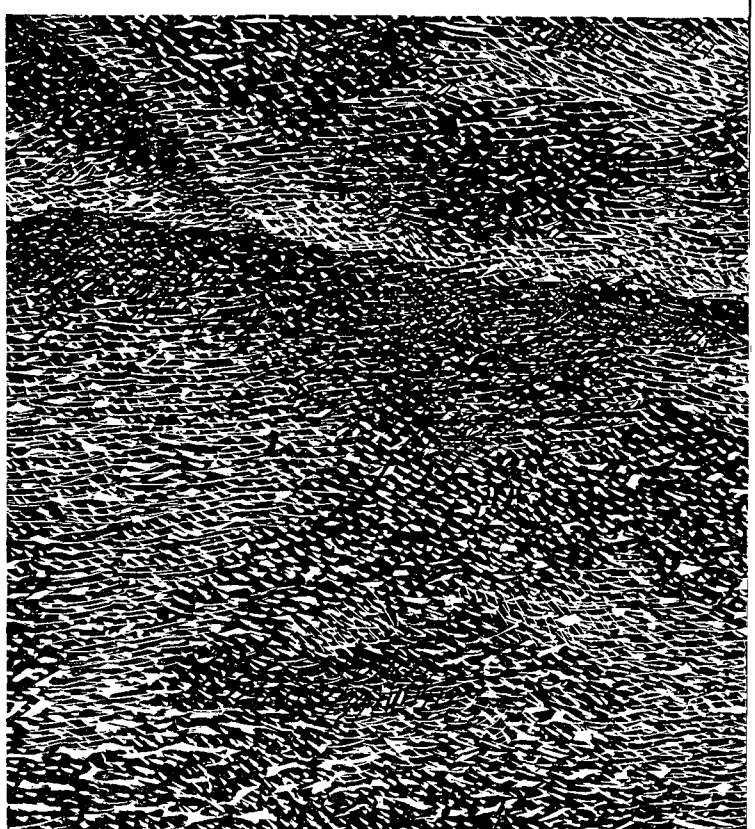
"What can you tell me?"

"That you're a fathead. Now shut up. I'm busy."

"Roger, Mike," Paul Cleary acknowledged quite meekly.

So I started again, reaching with my leads from point to point. After a certain number of tests, I had the area isolated, but not the part. From here on it would have to be disassembly. Every tiny screw had to be heated, then teased out with a jeweler's screwdriver. Some took my patented ratchet extension. The big miracle was that I didn't break anything.

When I got to it, it was ridiculous. A small length of wire connected one component to another. Space was lacking, and the wire was tight against the metal of the gate. Its insulation was one of these space-age wonders, a form of clear plastic that would remain ductile under



zero temperature and pressure. Only it didn't. It had shrunk and cracked, and there was a simple short against the metal of the gate. There were so many forms of circuit-breakers and self-protectors in the machine that the whole gate had been switched off as long as the short was in existence. No wonder telemetry hadn't told us anything.

As I prepared to fix the trouble, I switched on my radio and had Sid connect me with the ground. "Canaveral Control," one of those emotionless voices said. He could afford to be. He was on the ground.

"Get me Cleary," I ordered.

"Cleary here, Mike. What have you found, boy?" He sure was anxious about that solenoid.

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"Not much, Paul. Just that Fred Stone is a fathead, too. Over and out, like they say." I switched off and went back to my work.

The one thing I had nothing of was any kind of insulating material. With my screwdriver I hacked a piece loose from the double-faced sticky-tape I had used to keep loose parts from flying around, and teased it under the wire with my tweezers. Perhaps I could have done as well by heating the wire and bending it straight, but there was little room, and I was afraid of melting a solder joint. So I took my time teasing the tape through and finally got it to act as an insulator without breaking the wire. How long it would stay there was anybody's guess. It was held mechanically as well as by its sticky action, but when the bird cooled off enough, the sticky effect would lessen. I hoped the pressure between the wire and the gate could be enough to keep it in place. Certainly no forces would be acting to move it.

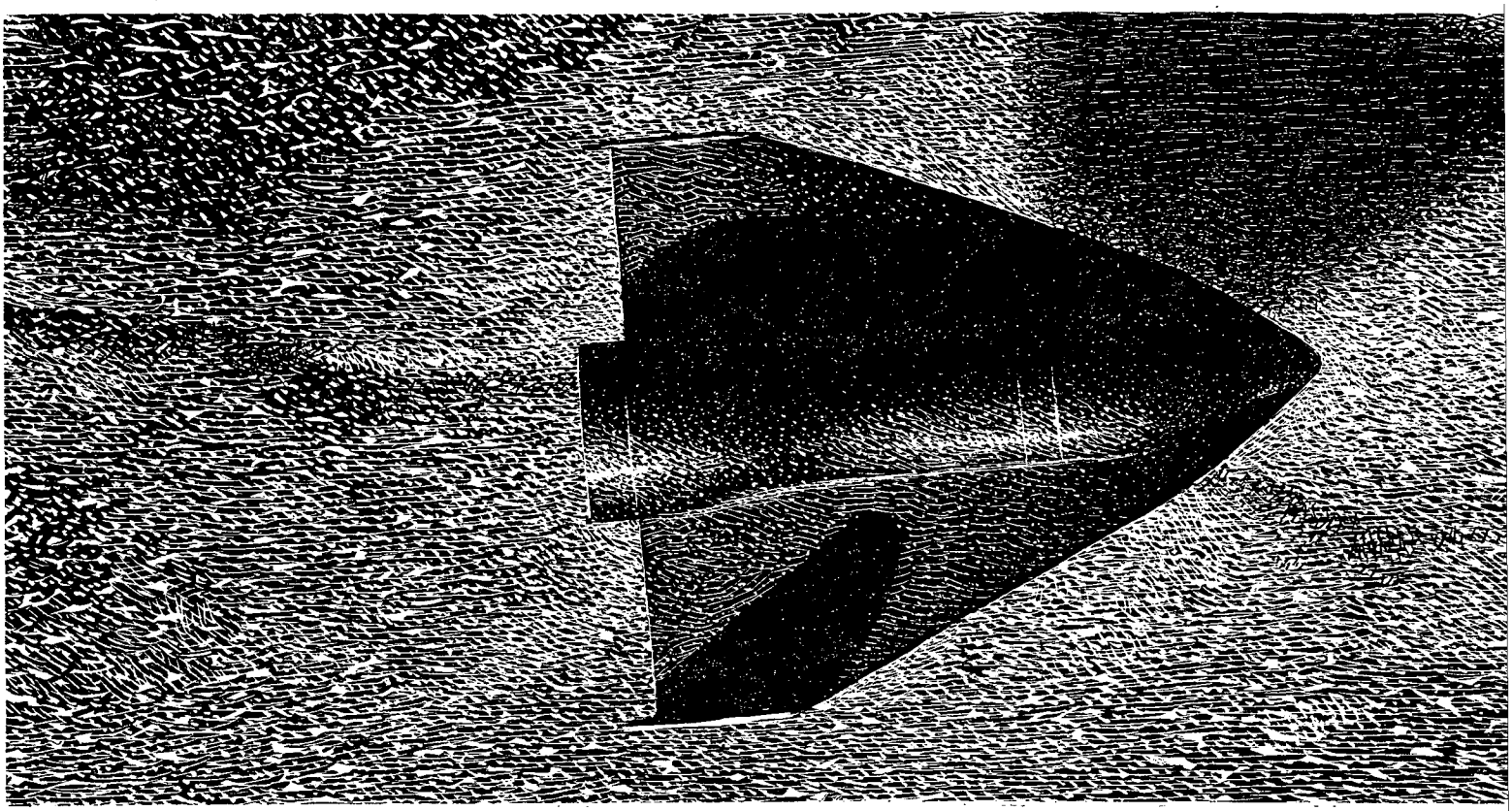
Just as I had figured, the reassembly was the tedious part. I had to move around into about sixteen screwy positions to do all the fixing. Finally it was back in one piece and I swung the gate closed.

When the final 4-40's were run up as tight as they were supposed to be run, I reported to Paul Cleary. "Try her," I suggested. "I think I found the trouble. No point my coming back down if it doesn't work."

They made me sweat it out for about ten minutes before Paul said, "Runs like a watch, Mike. Put the spin back on her, boy." At least he was quiet about his solenoid.

This called for the second rocket canister, which I hooked on to the girdle and, after thinking it out carefully, got headed in the right direction. I eased away with finger pressure, and let the delayed fuse do the firing. Telstar started her slow spin again.

Getting the girdle off was a lot harder than getting it on, something we hadn't figured on, and in the final stages of the job I found that my steering motors no longer fired.



"Sid!"

"Roger, Mike."

"How much fuel do you read in my steering jets?"

"You've been out of fuel for about five minutes, by my gauge. But don't worry about it," Sid said. "I'll nurse *Nelly* over there with my steering jets and pick you up."

"O.K.," I said doubtfully. "But watch it. Bump this bird and we'll have it all to do over again."

Sid had more trouble than he had figured. He had steering jets to run him in every direction except fore and aft. For that motion the retro-rockets were considered enough. But one belch out of them was enough to get me screaming into the mike: "Cut those retros!" I

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yelled, the volume making my earphones crack, as it undoubtedly did his.

"Roger. What's wrong?"

"You'll burn the solar generators right off the bird, you fool! Steering jets, do you hear, steering jets!"

"Roger."

But it was not that easy. Finally Sid got *Nelly* within about twenty feet, and pretty near at zero relative velocity.

"All right, Sid,,' I said. "Hold it there. I'll push over."

A gentle shove against the side of telstar was all it took. I got it straight, which was all that counted. My drift was slow, and I was a good five minutes making the twenty-foot crossing. But a handhold came within reach, and I worked my way back into the cabin and climbed in without shutting the hatch.

"Don't try that again," I cautioned him. "This thing weighs ten thousand pounds, and that bird half as much. Even at a couple feet a second, you can crush me to jelly between them, even if you don't burn one or the other of us to a crisp."

"Roger," Sid said, not quite so emotionlessly. "Are we ready to move?"

"What for?" I asked him. "Until we get me some steering fuel, I'm useless."

"I thought we'd abort this mission before we were through," he sneered.

"Not so fast. You've got the same rig on your suit. All we have to do is put your fuel tanks on my suit."

"Are you nuts?" he demanded.

"What's the matter with it? Those tanks aren't welded to you, and I've got tools."

I could see him shake his head in the dim light from the instrument panel. "You know those fuels ignite on contact with each other," he pointed out. "If we spill a couple drops of each in here, and they vaporize, we'll blow this kite to pieces!"

"Then we'll get outside to make the switch," I insisted. "It won't hurt anything if a few grams burn up out there, will it, with nothing to confine the expansion"

"But then I won't be able to come after you if anything goes wrong," he pointed out. "No dice."

"You're grasping, Stein," I growled. "At this stage I'm in charge around here. I'll take my chances on getting back."

With the cabin light on I went as far as possible in dismounting both our tanks. After a couple rehearsals to make sure that at least one of us would always have a glove on a handhold, we both climbed out the hatch and I made the switch. Just as Sid suspected, we spilled a few drops. They vaporized, and again as we had feared, combined in what would have been an explosion in a confined space. The soundless flash, dim but real, said we had released quite a little energy uniformly all around us. I never felt a thing except a faint warmth from infrared through my helmet.

Best of all, my jets worked. We both climbed back aboard *Nelly*, dogged the hatch, and started after Telstar Two.

The second bird was about fifteen thousand miles ahead of us. I slept most of the time, for after Sid gave us a jolt of added velocity, we had to settle down to about six hours of drifting. I woke up as the belt cut me when he fired the retros. We went through the radar and searchlight bit, and had the devil's own time finding our bird. But at last I got the flash of reflection and went to work.

I won't say the second job was any easier, except for the fact that I removed only one part to make room to do my bit with the insulation, and thus had very few screws to replace. My navigating in space was a lot better, and I didn't use steering fuel as wastefully as the first time. Still, when we dogged down to chase after the final bird, the cabin gauge said that I had less than half my load of steering fuel left. Equally glum, *Nelly* herself was even lower on steering fuel. Neither Sid nor I had been as expert as we were supposed to be.

Nevertheless, we took off after the third bird, and found it glistening in bright sunlight without the help of the searchlight. I thought that was a good omen. But from there on nothing seemed to work right.

We had been aloft about thirty-six hours, and fatigue was setting in. I was clumsy on the steering and had quite a time making contact.

The repair went according to Hoyle, but after I had put the spin back on the bird I found that I had no more steering fuel. I hung about ten or fifteen feet from Telstar Three and maybe eighty feet from *Nelly*, drifting slowly from both.

"Sid!"

"Roger, Mike."

"This one will have to make it with the girdle on."

"Can't you get it off?"

"I can't get back to it. Steering fuel gone."

"Oh, no!"

"No sweat, Sid. It occludes a small share of the solar generators, but not enough to hurt anything."

"That's not what I meant," he said quietly into my ear. "*Nelly's* out of steering fuel, too. I can't pick you up!"

I gulped on that one.

"Canaveral Control!" I heard him call.

"Cut that out," I said. "They can't help. Shut up and let me think."

But he didn't, and I couldn't. I had no fuel with which to move. Sid had only the retros and stern rockets, no good for swinging or turning. I was out of touching range of the bird, and couldn't shove against it to build up a little drift. Just as Sylvia said, it's not like swimming back to shore.

There was a lot of excited chatter in my earphones, in which I did not participate. Nobody made any sense, and Sid shut the thing down.

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"Mike!"

"Yeah." Disgusted.

"Whatever you dope out, make it quick. You don't have all the air in the world." Sid warned me.

"How much?"

"Ten minutes or so."

"All right," I said. "It ought to be enough. Keep your eye on me. You may have to reach out an arm or leg for me to grab as I go by."

"How are you going to move?"

"I've got a lifesaver," I said.

I writhed and squirmed and made every use of the law of conservation of angular momentum until I had my back to *Nelly*. Then I wound up and threw my fancy screwdriver as hard as I could heave it away from me. I didn't get the zip on it I would have liked, but because it was sort of like a throwing stick, I got a little more on it than you might expect, maybe fifty or sixty feet a second. And the thing weighed about four pounds, with its fancy ratchet and torque clutch. Since in my suit I weighed just about a hundred times as much, I started toward *Nelly* at just one-one-hundredth of the velocity I had imparted to the screwdriver. In a couple minutes I was drifting pretty close, but tumbling. I had forgotten that part.

Throwing the screwdriver had given my body the correct vector and some velocity, but I had set up quite a tumbling moment, since I had thrown from the shoulder and not from my center of gravity.

I chucked a couple lighter tools away to correct my drift, and Sid snagged me as I drifted by the hatch.

"Come to Papa," he said, and drew me inside. We didn't horse around congratulating ourselves. My air tanks were no longer hissing, and we made a quick swap.

Sid let me dog down the hatch while he figured position. He used the iron compass method, just taking a close look at Earth, which was more or less dead ahead of us. That was a good place for it, because we had no steering fuel.

The re-entry was a mess, from Sid's point of view. We came in at a weird angle and heated up to beat hell before there was enough atmosphere for our rudder to swing us around straight. He bounced us off twice after that as we slowed down, but the creak of heating metal was all about us each time we dropped in. He cussed me plenty all the way.

The trick, of course, was to slow down to the point where he could spiral us down to Muroc Dry Lake. *Nelly* was a sort of glider. Her performance at about Mach 10 and two hundred thousand feet was quite respectable, but the lower and slower we went, the more she flew like the proverbial kitchen sink. Sid only had one bright spot: Our big fuel supply gave him plenty of rocket and retro when he wanted it, and allowed him to get us back over Muroc.

I can't say he made the landing look easy, because he didn't. It looked like plain hell to me, for we scorched in at something over four hundred miles an hour.

When *Nelly* screeched to a stop, we just sat there. There was none of this romantic business about snapping open face plates and exchanging witty remarks. Bubble helmets don't have face plates, and besides, I didn't have anything I wanted to say to Sid. I was as tired of him as he was of me. I was just plain tired, if you want to know the truth.

They didn't let us alone, of course. While the crash trucks were still kicking up a dust trail tearing out to get us, there were guys on the radio with those cool voices, and Sid was tiredly saying "Roger," to all their questions. And we didn't do any moving about. You'd be surprised how weighing four hundred pounds makes you willing to wait for the crane to lift you from your seat. All at once I almost wanted to be back in space again, where I didn't weigh anything at all. Almost.

They flew us back to Canaveral for the de-briefing, both asleep. The whole mob was there to greet us, Paul Cleary, Fred Stone, and even Sylvia. They met us at the plane and Sylvia was the first to grab me as I came down the steps.

"Mike!" she squealed. "Are you all right?"

"Better now," I said, kind of untangling from her. "How did you manage this?" I looked up. "Hi, Paul," I said to his sleepy old grin, and knew how.

"Dinner tonight?" she insisted.

"I don't know," I said, looking over at Paul. "I think there's a de-briefing or something before they turn me loose."

"Don't be silly," Sylvia said. "It's not as if you were an astronaut or something."

I was back on the ground, all right.

Well, there was sort of a de-briefing. Cleary and Stone got me alone for a moment in somebody's office.

"Well, Mike," Paul said, "that was a great performance. What was the trouble up there?"

I laughed at both of them. "Go jump in the lake," I said. "I'm out of the middle."

"What do you mean, Mike?" Doc Stone asked, holding his young-man's pipe at arm's length.

"It wasn't design—because the solenoid worked. And it wasn't installation. It was materials." I told them about the no-good insulation.

"Lucky it's only used in a couple points," Paul said, scowling. "I guess any other point where it broke up wasn't as critical in dimension and no short resulted."

"Not yet," I grinned. "It may. And I couldn't care less."

"You're a big winner, then, Mike," Paul grinned. "Fred and I have kind of made up anyway, and you're in solid with Sylvia."

"Not with that noise," I said. "No dame was worth that ride. Let Sid have her." ■

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HERMIT

You can have a man with ingenuity and adaptability—or you can have a man you can depend on. But not a man who is both! by **J. T. McINTOSH**

ILLUSTRATED BY GEORGE SCHELLING

When the ship first showed on the screens, he naturally didn't believe there was really a ship. Two thousand light-years from the nearest inhabited world you didn't expect to see unannounced ships. However, he ran to the slushpile at once in case he'd missed a warning about some possible, if unlikely, official visit. If he had, he missed it again. This was easy to do, the slushpile being a stack three feet high.

Back at the screen, he saw it was no longer possible to doubt that what he had seen was a ship. He had the usual moment of shock, excitement, anticipation and fear as the thought flashed through his mind—as it flashed through the minds of most watchers of the skies when they saw a ship where no ship had any right to be—that this might be the first contact with a nonhuman culture.

But as usual the ship proved to possess familiar, obviously human-designed contours. She was a small, slow two-jetter, probably a tender from a larger vessel, and she was making straight for Experimental Station 47.

"That puts you right on the horns of a dilemma, son," Duncan Clement said aloud. By the time you'd done nearly ten months out of a year's solo duty, you were doing all right if the worst you did was talk to yourself. "Officially you've got no choice but to blast that ship right out of space. But if you do that you'll be told afterwards that while you were technically in the right, anybody with any sense would have at least *tried* to find out what ship she was and where she was from before blasting her. And you'll also be told that you might at least have given her a chance to stay clear."

He didn't have to switch on the radio. Already it was automatically beaming a stentorian command: IDENTIFY YOURSELF AT ONCE. IDENTIFY YOURSELF OR BE DESTROYED. IDENTIFY . . .

The automatic message gave nothing away. It did not announce: "This is Experimental Station 47." The recipient of the message, if any, might not know.

There was no answer from the ship.

From the information automatically being collected about her, Duncan saw that she must, as he had suspected, be an escape vessel or landing craft from a larger ship. Her range could be no more than half a light-year. What such a vessel was doing three thousand light-years from any regular cargo and passenger run was anybody's guess.

The radar and other warning devices being extremely efficient and the ship being very slow, Clement had plenty of time to consider what he was going to do. Not, however, nearly enough time to report to HQ on Earth and get an answer. By roboradio that took about eleven hours and he had less than two to spare.

His orders left him no discretion. Had the ship been alien—well, that would have been different. Even Terran HQ balked at the idea of giving ESOs ironclad orders about how to deal with a situation of such significance and uncertainty. The ship not being alien, Clement was permitted merely to warn her to stay clear. If she did not acknowledge his messages and did not stay clear, his only choice was the precise method of her execution. ES47 being a weapon-testing station, this choice was wide indeed.

He was not allowed to fire warning shots of any kind. These might provoke retaliation, retaliation which might —miracles sometimes happened—do some damage. When he struck, the first stroke was supposed to be final.

But Experimental Station Officer Duncan Clement was in no hurry to execute the standing order appropriate to the circumstances. He was not afraid of the little ship. Her potential power, umpteen million miles from one of the greatest arsenals in space, was negligible.

First he checked the slushpile more carefully.

Experimental (Weapon-testing) Stations, most of which could be reached only through hyperspace, were safe from inspection by top brass, but they could not expect any mercy in the matter of orders, memoranda and special instructions. Like all other military depots, ES47 received month after month reams and reams of messages from scores of heads of departments. Since the entire staff of each station consisted of one man and since the messages received would have required an office staff of five for proper attention, nothing was ever done about the slushpile. The memoranda piled themselves neatly in stacks which the ES Officer never even looked at unless, as in this case, something happened.

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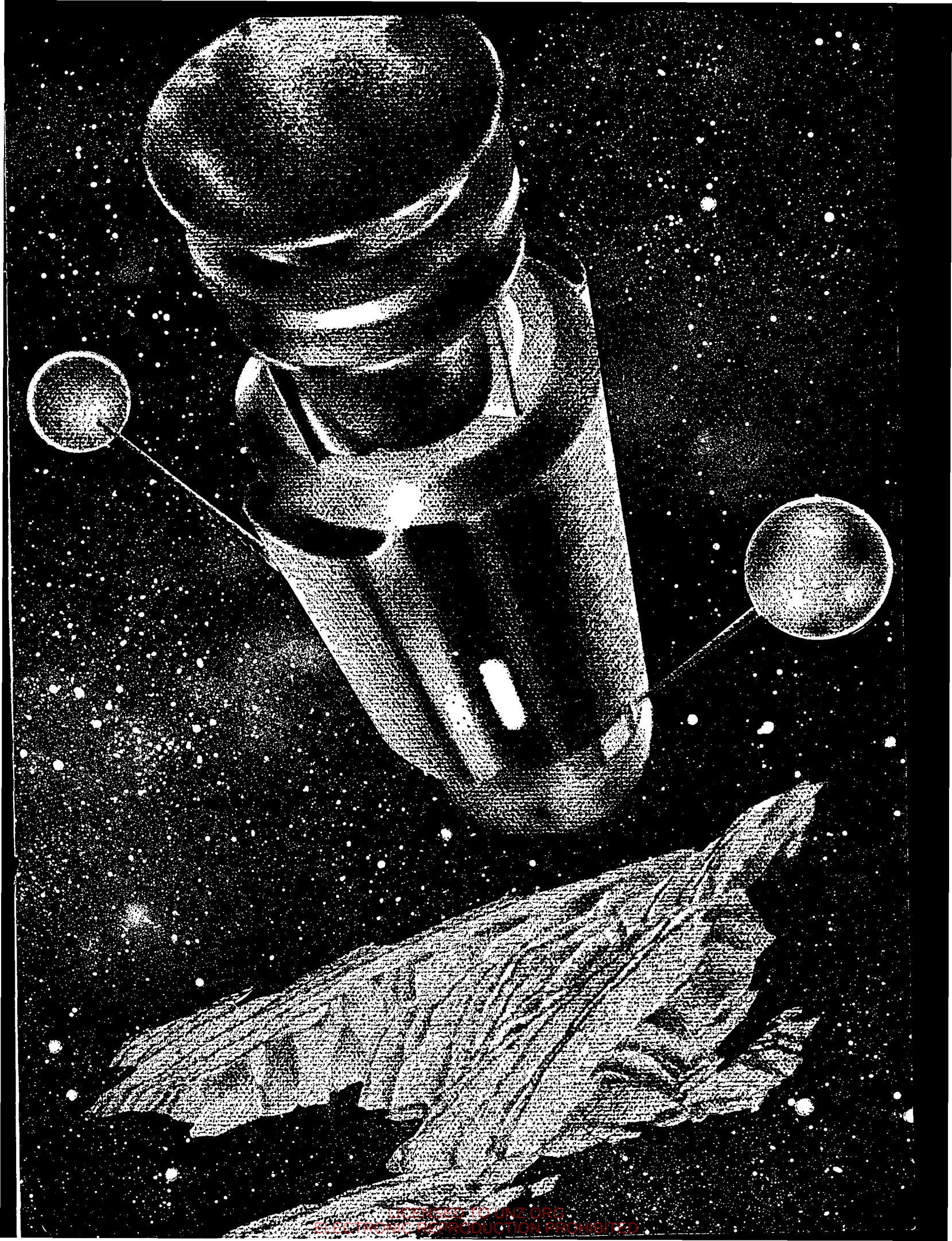

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Urgent messages, for immediate attention, were automatically delivered to the ESO in his quarters whenever they arrived. But since the Communications Officer at HQ was human, urgent messages were reserved for urgency, despite the requests of various heads of departments all of whom believed that nothing mattered except their own line, and that anything that happened in their department, however small, was of galactic importance.

Clement scanned back over the memoranda with the Security code on them. He found three reminders that unidentified ships which approached secret stations must be blasted out of space before they got near enough to do any damage, and he also found an instruction that if any ships were sighted their presence must immediately be reported to HQ with the fullest possible details about their size, armament, type and nationality. (Please supply the following information before I destroy you.)

Then he found a message which he read carefully.

> An organization known as the Peace Convention has opened a campaign of what it calls active pacifism. All personnel are warned that this organization has the frank aim of destruction of all military installations which could be used in war. As yet Peace Convention agents have been careful to safeguard the lives of military operatives while attempting to destroy war potential, but it must be remembered that these men are fanatics who believe that the means justifies the end.
>
> *To ES Officers only*: Experimental (Weapon-testing) Stations, containing a vast amount of armament and war material generally and manned by a single officer, would seem to be a glittering goal to Peace Convention agents. The latter have shown themselves reluctant to destroy large numbers of men in putting relatively small quantities of water material out of action. Their record, however, indicates that the destruction of the material contained in any Experimental Station at the price of the death of a single ESO would seem highly desirable to the Convention. Special vigilance is recommended.

The memorandum was dated three months previous.

"So," said Clement aloud. "We had no choice anyway but to destroy any ship we saw. Now we've got even less."

He went back to the radio, which was still sending out its strident command. No reply had been recorded.

Cutting off the automatic signal, he sent a live message.

"You in the ship, whoever you are," he said, "I'm going to give you five minutes to start talking. If you don't talk, I'm going to try a reaction beam on you. That's supposed to convert your momentum one way to momentum the opposite way, but don't blame me if the effect is considerably more fatal. You in the ship, do you hear me?"

He was fully aware that he was disobeying orders in giving the unidentified ship this much of a chance. If there had been an Earth-based general present, he would have been quite prepared to tell him exactly what he could do with his orders.

After a couple of minutes a voice came on the air. "I hear you." That was all it said, but it was enough to add an unexpected new development to the situation.

The voice was that of a girl.

"How many on board?" Clement demanded.

"Just me. Lesley Kay. And I understand you're alone on that lump of rock. Cozy, isn't it?"

Crazier and crazier. You didn't find a ship, even a lifeboat, a couple of thousand light-years from anywhere with only a girl on board any more than you found an ocean liner in the middle of the Pacific with only a girl on board.

On the other hand, if there was a bigger ship somewhere in the vicinity, it might seem like a very good idea to send down a girl alone to soften up the solitary ESO on his lonely lump of rock. The idea had been known, and had worked, since the dawn of history.

"Cut the drive," said Clement. "Better still, move back and go into orbit."

"I can't. I don't know how. This thing is set to home on a planet. Your slagheap is the only thing it can find. It's going to land. I can't stop it."

"Tell me how you come to be here," Clement said. If her story made sense, he was left in the same position. But if it didn't, if there was a flaw in it or if it was too starkly incredible, he would be assisted to a decision.

"I was on the *Pericles*, bound from Klempis to Rigel," the girl said. "She got stuck in hyperspace and we were warned we might land up in the wrong galaxy and not be able to get back. The captain said that anybody who wanted to take the chance of dropping off practically anywhere in this galaxy could be ejected into normal space in a lifeboat. I was the only one who chose the lifeboat."

"And they let you go alone?"

"When it turned out I was the only one, the captain wanted me to stay on the *Pericles*. But I said he'd given a promise, and in the end they let me go."

Offhand Clement had no idea whether a lifeboat ejected into normal space from a ship on the Klempis-Rigel run would end up anywhere near ES47. It would require long and careful calculation. But he could and would do it, given time. Both Klempis and Rigel were over twenty thousand light-years away. In hyperspace travel, however, the shortest distance between two points was not a straight line.

Otherwise her story, couched in the completely non-technical terms which were only to be expected, was not unreasonable, nor was her decision. Hyperspace fixation

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was by no means unknown. Exactly the right conditions had to prevail before switching from hyperspace to normal space, or vice versa, was possible, and no captain would attempt it if there was the slightest flaw in his ship's drive. He would have the fault fixed first, even if that meant emerging in Andromeda, and then attempt to get back. Since the chances of ever getting back were about fifty-fifty, Clement could understand the girl's determination to stay in the right galaxy rather than stick with the ship.

"You know I'm the only man on this planetoid," he said cautiously. "How? And what else do you know?"

The girl laughed. "I'm Lesley Kay, I told you. My father's Senator Kay. I know about Experimental Stations and how they're run. I know you're not supposed to let me land—but what harm could I do?"

She was pretty sure of herself. A spy or saboteur might act that way. So might the daughter of a senator if she believed, as this one evidently did, that everyone must know who Senator Kay was. (Clement did not.)

He made up his mind. It would take more than an hour to check out the position of ES47 with all possible hyperspace loci on the Klempis-Rigel run. He had not yet decided what he would do if her story was possible. If it was not, he'd blow her out of space.

"I'm signing off," he said abruptly. "There's something I have to do."

"No need to make a special effort for my arrival," she said. "Just sweep the place out and put on your best uniform. I don't expect anything more . . Wait, don't cut me off." Her voice became more serious, more earnest. "Listen, I'm not a tramp, I'm not cheap. But I do want to live. As it happens, I'm entirely in your power. I've told you I can't handle this ship. I can't do anything but let her land. Well . . I told you I'm not cheap."

"I've got the message," said Clement dryly. "Want to add that you're eighteen and last year's Miss Universe?"

"I'm seventeen, not eighteen. About my looks, you'll have to decide for yourself."

"So you're ugly."

There was a sudden snap in her voice. "I don't want to get blown to pieces, but I've debased myself as far as I'm going to do, Mr. ESO."

"Duncan Clement," he said, and cut her off.

The task of calculation took longer than he expected. The lifeboat was very near by the time he had established that if an escape vessel left the *Pericles* during her twentieth day in hyperspace, she could emerge in normal space about two hundred million miles from ES47. That was his answer, for what it was worth: he was working in approximations and had only really managed to establish that Lesley Kay *could* be telling the truth.

He made up his mind. Orders or no orders, he was going to let her land.

All along he had had to fight down his anger at having to make his decision under the Damocles sword of HQ's edict that there was no decision to be made.

He had also had to try hard to do the same as he would have done if the Kay girl had been a man. This was, of course, next to impossible to be sure about. He knew she was a woman and he had not seen a woman for nearly a year. It was one thing to decide quite calmly that for a year he would see no women, and no men either. It was another to bring himself not merely to reject a miraculous offer of female companionship but also to annihilate a girl of seventeen who might well be innocent of everything except approaching too near to an Experimental—Weapon-testing—Station.

He tried to raise her on the radio but failed. He was not surprised—although lifeboats set as she said this one was set were supposed to land themselves automatically, it was hard to be confident about it. She would be staring at the screens and the controls and wondering if there was anything she should be doing, if she knew how.

Anyway, what was there to say? It was pointless to insist that she should stay well clear of the planetoid. If she was a saboteur she might be able to handle the ship better than she admitted, but if she was a saboteur she wouldn't stay clear. If she was telling the truth, she probably couldn't handle the lifeboat at all.

The mass of ES47 being small, the automatic pilot had no great difficulty in landing the lifeboat. But the little ship landed miles away—ten miles, Clement guessed. He waited for the radio to open up again, asking him to come out and help the girl to safety. His suspicions were further allayed when it did not. On landing, the lifeboat would switch itself off completely, and it would need some know-how—not much but more than an ordinary girl passenger could be expected to possess—to switch on again.

He switched on the beacon on the roof of the station. If Lesley Kay didn't know enough to put on a spacesuit correctly, or lacked either the strength or the resolution to travel ten miles in inky blackness over icy lava, she was going to die, for ESO Duncan Clement was not going out to get her. What a setup that would be—the ESO out of his station, leaving the place wide open for anyone to walk in—though there were, of course, certain very considerable safeguards.

Clement knew he should send a message to HQ. He did not. Instead he went around the main control room taking a last look at his pin-ups. The walls were covered with them. One by one he tore them down and threw them in the disposal chute. He did not want to give Lesley Kay the impression that he was sex-starved, though this was obviously true. More important, he didn't want her to think she could control the whole situation by wiggling her hips. That wasn't true at all. ESOs were very specially selected men.

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Lesley Kay did not die. Seventy minutes later Clement saw her bounding nimbly over the rocks. Ten miles an hour in less than ¼G, even over broken rock faces, was average going for an athletic person of either sex.

He let her operate the air lock herself, let her remove her helmet. When she turned he was holding a gun on her.

She grinned. "Is that necessary? You let me land. Frankly, I was worried about that. But having let me land, you're got going to shoot me now—"

"Get your suit off," he said.

"Willingly. I knew it would be hot but I didn't realize how hot." She put down the box she was carrying. Clement pulled it well clear of her, opened it, rummaged through it. Clothes and a few books. Nothing else.

The girl emerged from the heavy spacesuit as if from a chrysalis. She was a golden blonde, of average height. As far as her face was concerned, it wasn't inconceivable that she could have been a Miss Universe. Her figure—Clement had never seen a girl in a spacesuit before—at first seemed very heavy, and then too thin.

When she stepped out of the now rigid legs of the suit he not only saw that her figure was gloriously right. He saw nearly everything else. She had stripped to a couple of wisps of black underwear before putting on the suit.

"Now that you've made a full inspection," she said coolly, "may I put on a dress?"

"No," he said, kicking the box away. "Stand there for a minute."

Maybe someone was trying to be very smart, too smart. Could a lonely ESO shoot a beautiful girl who made her first appearance in black underwear? On the other hand, would a beautiful girl who was exactly what Lesley Kay claimed to be, no more and no less, voluntarily introduce herself in a strip of low slung bra and abbreviated panties?

Clement didn't think so. His suspicions, which had shrunk almost to nothing, swelled again.

But at least he could be sure that she had nothing concealed. Nothing in the way of a weapon, at any rate.

"Go in there," he said, pointing with the gun.

She made a move toward the box.

"As you are," he said. "That's the emergency quarters. There's a bed there if you're cold."

"This is silly. You and I are the only two people within—"

"Do as you're told," he said coldly.

She was for the first time angry and didn't mind letting him see it. However, she went through the door he indicated.

Clement locked it behind her. Then he examined every article in the box and took the spacesuit to pieces.

On the face of it, everything backed her story. The spacesuit was engraved *Pericles* and the serial number was about right. So was the type. Inside one boot was a scrap of paper which turned out to be a piece of towel tissue marked Merino Lines. *Pericles* was a Merino Lines ship.

The box was a trunk cabinet from the *Pericles* and the closest examination showed nothing which ought not to be in it.

Having finished his examination of all the girl had brought with her, Clement did what he should have done some considerable time ago—sent a roboradio message to HQ. He had some excuse for the delay—the number of messages he could send was strictly limited.

Ordinary radio was useless over distances running into light-years. Hyperspace acted differently: a different kind of radio wave traveled faster in hyperspace. To send a message, however, Clement had to send a radio capsule into hyperspace. His message, relayed there, traveled a relatively short distance—if you could talk of distance in hyperspace—and was picked up by another radio capsule which then returned itself to normal space near enough Terran HQ to relay the message fairly rapidly.

The system was clumsy and expensive, for although the radio capsules employed were supposed to return automatically to their base, few of them ever made it. Consequently ESOs and HQ stuck to the regular two-monthly bulk transmissions as far as possible. Special messages were kept to an absolute minimum.

So Clement had a good excuse, outside of his decision to let Lesley Kay land at all, for waiting until he had as much as possible to report.

He gave such facts as he possessed as fully and fairly as possible, inquired about recent Peace Convention activities, and asked for instructions. His tone was neither cringing nor aggressive.

Having sent out the radio capsule, he considered going and examining the lifeboat. Not yet, he decided.

Then he opened the door of the emergency quarters and let the girl out.

She was still angry. Without looking at Clement, she went to her box, pulled on a sweater and slacks and thrust her feet into sandals. Then she said: "I hope you're satisfied now. I didn't expect—"

"We'd better get a few things quite clear from the start," said Clement grimly. "You know that I should have destroyed your ship the moment I sighted her."

"Well, that may be the theory, but—"

"It's no theory," Clement snapped. "I'm in the same position as a sentry. If a stranger doesn't obey my command to halt and identify himself, or doesn't have a satisfactory answer, it's my job to shoot him. Or her."

"But I had a satisfactory answer."

"You did not. The only satisfactory answer is that you're empowered to land by my superiors."

"I told you my father—"

"Please rid yourself of your Electra complex. Your father could be the President and it wouldn't make one cent's worth of difference."

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She was cool again. "Then why let me land?"

"Because I'm crazy, I guess. Because I'm to be relieved in two months and you could be picked up then. Because I didn't want to kill you, or anybody. Because you might be just what you say you are, a space refugee. But, if there's to be any pretense of friendliness between us, you'd better realize that all the time you're here I'm never going to let you out of my sight except when you're in the emergency quarters and locked in."

Lesley laughed. "I'd have thought it would be the other way round," she said meaningly. "That I'd lay the conditions for . . . friendliness, not you."

"That just shows how little you know about the situation."

"You mean you've been here for ten months alone and yet you can act like a jailer when a girl—"

Clement was on his feet, his gun in his hand. "Back where you came from," he said softly. "In there."

She didn't move. "What now?" she said wearily. "What did I say? Or what did you think I said?"

The gun pointed unwaveringly at her. "You knew I'd been on solitary duty for ten months. How?"

"Because your tour of duty is a year and you told me you were going to be picked up in two months."

The gun dropped. Clement put it away, cursing himself for having put himself at a disadvantage.

"You seem to know a lot about Experimental Stations."

"So I do. What do you want to know? Weapon-testing hasn't been possible on Earth or even in the Solar System for a long time, since wide open spaces ceased to exist and since the weapons to be tested became so numerous and so powerful that millions of cubic miles became necessary . . . So a series of weapon-testing stations was set up out in space, in locations which could only be reached through hyperspace. Each of these stations is manned by one ESO . . . Why only one? Because the stations are top secret and the accident rate is high. Screening twenty men per station, before and after their tour of duty, and thinking up lies to explain what happened to them if they get killed, is too big a job. Besides, a station can be keyed to one man but it can't be keyed to twenty—"

"So you know about that, too." He was shocked. What was the use of rigid military security when senators casually passed on top-secret information to their families?

"Oh, sure. So you needn't keep drawing that gun on me. We both know that if you happen to die, the whole station will lock itself up so thoroughly that I'm almost sure to die, too. Even the pantry door wouldn't open for me."

Clement didn't know what to say. If he had been aware in the first instance that this girl knew so much about Experimental (WT) Stations, he could have acted differently. He needn't have tried to be so coldly military, knowing there was nothing to be gained. It was hard suddenly to take up an entirely different attitude.

She seemed to realize this. She stood up. "Now I'll voluntarily retire to my cell," she announced. "I've been awake for twenty-seven hours. Tomorrow we can start not snarling at each other, huh?"

He let her go and once more locked the door behind her.

If she had really been awake for twenty-seven hours, there was a good chance that she would not reappear for twelve hours or so, by which time he should have a reply from Terran HQ.

It was pretty clear that he would have to go out and look at the lifeboat. Lesley Kay could still be a spy or a saboteur. For that matter, there could be men still on the lifeboat, men who were waiting for him to walk into a trap. If so, it was hard to see what good it would do them if he did. Lesley knew that the station was keyed to him so thoroughly that no door would open, no switch would operate except for him.

There was no food in the small suite of rooms in which she was locked. If anything happened to him, she would starve to death.

Clement put on a spacesuit and started out in the direction of the lifeboat.

The weight of responsibility on his shoulders had quite prevented him so far from finding the girl desirable. He wouldn't have thought this possible but it obviously was. Had he not had a strong sense of duty he would not be where he was. The beautiful blonde who had deliberately introduced herself to him looking as desirable as she knew how to be was like, say, one hundred thousand dollars offered to him to betray his country or his world. He could not be tempted because his mind had been made up long ago about any and all temptations.

But that was on the basis that the girl was a liar. If she was not, the one hundred thousand dollars was not offered as a bribe. It was merely there—possibly available, possibly not. In such circumstances it became very easy to desire it . . .

As he bounded slowly and lightly from rock to rock, shining his hand torch ahead of him, Clement found himself seeing the blonde twice as vividly in his mind as he had done when she was actually with him. Then she had been first a problem, and a pretty girl a long way second. Now, surely, she was less of a problem. What harm could she do?

With an effort he banished the picture from his mind and concentrated on what he was doing. Although all falls were light on his nameless, barren kingdom, and he couldn't break his neck even if he fell on it, there was a danger in inertia. He could bound easily from a needle spur of rock, but if his leg sank into a cleft while he had a lot of forward momentum, his suit and his leg could be snapped.

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He found the ship only slightly damaged by the landing, but airless. She could not take off again without repairs. That simplified the situation—Lesley could not leave the planetoid in the lifeboat.

A careful examination revealed nothing in any way suspicious. She was a lifeboat from the *Pericles*, as Lesley said. Her automatic controls were still set on ES47, and he was able to establish that they had been set automatically, too.

On the way back, the image of Lesley as he had first seen her returned again, and this time he did not brush it aside.

Short blond hair, somewhat disordered. An intelligent, sharp, pretty face, rather thin-featured—the face of a girl who looked before she leaped. Pale, smooth, untanned flesh, ample only at bust and hips. Long slim arms, long slim legs.

And now he found her desirable. Now he believed she had been telling the truth. There was a strong connection.

Back at the station he went to bed at once and slept. The girl was a prisoner until he wakened and let her out.

When he did waken he dressed with unusual care, shaved, trimmed his hair. Then he went to the radio. The printer was still silent, although an answer to his message could be expected about now.

He went back to the main control room. Faintly he heard taps which indicated that Lesley wanted to come out. Ignoring them, he went back to the printer.

It started to chatter as he looked at it. The first words were:

EXECUTE THE GIRL CALLING HERSELF LESLEY KAY. THIS IS AN ORDER, AND MUST BE CARRIED OUT AT ONCE. YOUR OWN LIFE DEPENDS UPON IT.

There was more about the present situation. He waited until the printer arrived at general topics, then tore off what had already been sent and ignored the rest. For hours now the printer would go on tapping. Although two weeks remained to the date of the next and final bi-monthly communiqué, the Communications Officer naturally took this opportunity of sending all the routine memoranda as well as the emergency orders.

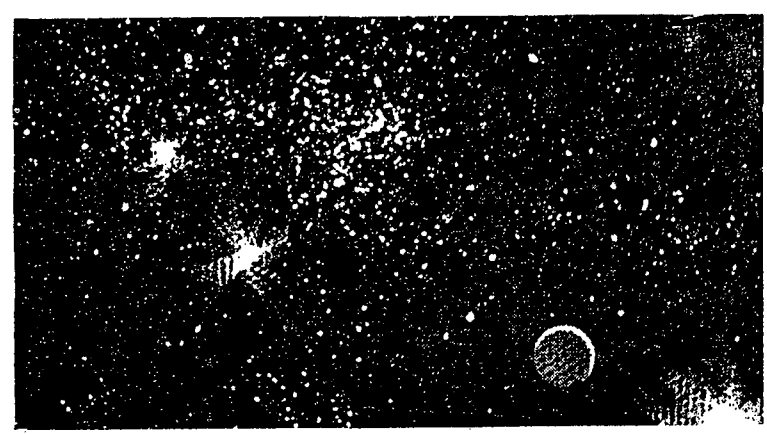
Somewhere within a few million miles the radio capsule Clement had sent out, having exchanged his brief message for this plethora of words, was beaming its heavy load to the printer. In the next week or two it might or might not manage to return to the station. If it did, it could be used again.

For the third time Clement scanned the meat of the messages the printer had run off in the first few seconds of transmission.

The Peace Convention had declared war on Experimental (WT) Stations—these "forts in space," it had called them. If they were not closed at once, the Convention would close them.

"What purpose is there in the development of even more terrible weapons?" the Convention demanded rhetorically. "No purpose but purposes of war. Yet the weapon-testing function of these storehouses of horror is only secondary. Their real function is to enslave the galaxy. They are forts where no forts would be needed unless the warmongers planned a colossal future war on the whole of creation . . ."

There was a lot of this, fairly persuasive. Why set up scores of one-man weapon-testing stations with spare accommodation, the Convention demanded, if not as military outposts? Weapon-testing could be accomplished much more quickly and efficiently by larger stations with more personnel.



There was not a word about the possibility that at some future date nonhuman civilizations might be encountered somewhere in the galaxy. The Convention either rejected the possibility as fantastic propaganda or ignored it because it might appear to weaken their case.

Fanatics or not, the Peace Convention could be dangerous. As far as Clement was concerned, their motives were irrelevant. All that mattered was whether their threats were just threats or something more. He was prepared to believe that they were a great deal more.

Important as the information about the Convention might be, of more immediate concern was the material relating to ES47 and to Lesley Kay—if she was Lesley Kay.

"It has not yet been possible to check out the Senator Kay angle. Probably there is such a senator and he has a daughter called Lesley. Nor has the passenger list of the *Pericles* come in yet. It will, of course, be several weeks, perhaps months, before the truth or otherwise of the *Pericles* story you have been told can be definitely established.

"However, there seems little doubt that your visitor is a Peace Convention agent, probably Ruth Brown

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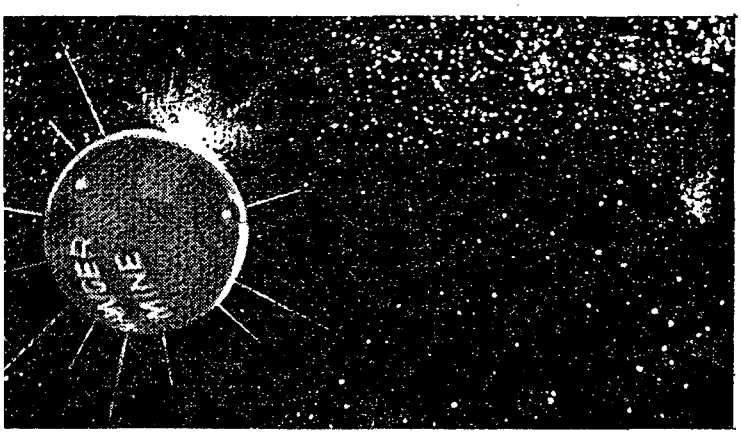
(description appended). *Confidential*: two other stations have failed to make their regular reports. It is feared that Peace Convention saboteurs may have succeeded in destroying them.

"Although you have disobeyed a strict, clear order, no disciplinary action will be taken over your allowing this woman to land, since you were unaware of the most recent developments. But you must execute her at once and destroy her ship after checking that it is safe to do so."

There was more, of course, much more. The description of Ruth Brown did not clinch matters. Ruth Brown was eighteen, five feet eight, brunette, one hundred thirty-five pounds . . . This alone, without the rest,



showed that Lesley was not Ruth Brown.

Less than twenty-four hours ago Clement had been trying to reach an honest decision about Lesley. He had reached it: she was what she said she was. (One niggling doubt: did a girl who was *not* trying to vamp a man make her first appearance in black underwear?) Now he was told to execute her.

It would have been easier to execute her if he had never let her land. Far, far easier. And even then it would have been difficult.

He checked his gun, crossed the room and unlocked the door. Lesley emerged. She was wearing a one-piece blouse and slacks outfit sober in every respect save that the neckline plunged sensationally to the pit of her stomach.

And she was smiling. "Start again?" she suggested.

"No," Clement said bleakly. "Read those."

She sat down at the desk and picked up the papers one by one. After glancing at the first she looked up, startled, but when Clement said nothing she resumed reading.

"Well?" she said at last.

"I have no choice."

"Of course you have," she said irritably. "There's always a choice. And you needn't pretend you're going to obey orders. If you were, you'd have shot me the moment I appeared."

He raised the gun and aimed between her eyes.

For a moment her face broke up, went to pieces. Then she said semihysterically: "Look, I don't want to die, but make up your mind. If you're going to do it, now or ever, stop playing with me. Pull the trigger and that lets me out. But if you don't pull the trigger, put the gun away and drop the subject once and for all."

The gun still pointed between her eyes. Surely she must break, if she was a saboteur? If she did, she was dead. Clement had no compunction about killing spies or saboteurs.

"Can't you do anything to assure yourself that I'm telling the truth?" she asked. "Haven't you a lie-detector? Scopolamine? Sodium pentothal?"

"No. We don't expect company," said Clement dryly. "If I were to leave you alive, it would only be for two months or less. When I'm relieved you'd be shot. And maybe me with you."

"Don't be a fool," she snapped. "They tell you now to kill me. But once the relief ship turns up, there won't be any danger any more. They'll take us away and they'll check on me and find I was telling the truth."

He was compelled to admit to himself that this was true. When the relief ship arrived, her captain, with a crew of twenty, would be utterly in control of the situation. Any threat represented by a single unarmed girl would be laughably minute. Even if she were proved to be a spy and a saboteur there would no longer be any question of summary execution. She would be taken to Earth for questioning.

"Tell me about the Peace Convention," he said.

He was alert for any sign of hesitation, of uncertainty. She would be making a bad mistake if she stalled, pretending she knew nothing about the Convention. The memoranda she had just read should have told her a good deal. And it would be strange if a girl who knew so much about Experimental Stations should be wholly ignorant of the Peace Convention and its aims.

"It used to organize disarmament marches," she said steadily. She seemed to be recovering from her temporary breakdown, although Clement's gun still pointed at her head. "It campaigned for peace alliances with everybody. For the abandonment of all weapon-testing programs. Then it split into two. There was a nonactive group carrying on the same propaganda work. And an active undercover group which organized acts of sabotage against war materiel and potential in all countries and colonies."

"In *all* countries?"

"The Convention is stronger in some countries than others, naturally. Strongest in the freest countries and colonies."

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"That points a moral, doesn't it?"

"That the freest countries are the most free, you mean? And the most just? That's a pretty obvious moral, isn't it?"

"Why aren't the people operating openly as Peace Convention agitators arrested?"

"Sometimes they are. But they can usually prove they have no direct contact with the active, undercover group. France and Italy have declared the whole organization illegal. The main result is that in those countries there's no possibility of parleying with the Convention. There's a lot of public sympathy with the Convention. After all, there's no war, no particular threat of war, only minor local disagreements and some friction with certain colonies. When War Departments are strong and there's no war, the tendency is for society to develop in the direction of national-socialism."

"How do you feel about the Peace Convention?"

Although she spoke calmly and clearly, there was no doubt that she was aware she was on trial. "Much as I feel about communism," she said. "Theoretically it's a good idea. In practice it's dangerous. You can agree with most of the Convention's propaganda without agreeing about what they do."

"How about the possibility of another intelligent race?"

"Huh?"

"Suppose there's another intelligent race in the galaxy. Wouldn't that make a difference? Wouldn't you as a human being be glad that these forts in space existed?"

She was frowning. "But there isn't another intelligent race in the galaxy. We've been running wild for centuries and never found one."

"Don't you know that so far we've only made the lightest, slightest contact with one-five-thousandth of the worlds in the galaxy? Don't you know that three times survey ships have found remains of nonhuman cultures only a few thousand years extinct—a mere instant of galactic time? Don't you know that six months ago an exploration ship found a planet abandoned only a thousand years ago—abandoned, indicating that the race concerned went elsewhere in the galaxy?"

She seemed to be forgetting for the moment that she was on trial. She was pensive. "Well, it might make a difference . . . But if there were another race about our level, would it be a good idea for us to shoot first? For Experimental Stations to blast their ships out of space?"

"If you know so much about these stations, you should know that while ESOs are ordered to blast unknown Terran ships, they have an absolutely free hand if aliens are encountered. But if they need it, they possess the ultimate in attack *and* defense . . ."

"Why not tell all this to the Peace Convention instead of to me?"

"You think it would be a good idea?"

"I think it would be an extremely good idea."

He was satisfied—again. Thrusting his gun in his pocket, he held out his hand.

She didn't take it. "Sorry," she said, with a nervous laugh. "I'm not used to being threatened one minute and being all pals together the next. You've been threatening to kill me since I arrived. You've got to give me time to get used to the idea of not being murdered."

He nodded. "Fair enough. It'll take me a while to get used to the idea of not having to murder you."

Clement's last statement was not strictly correct. He had decided not to kill Lesley; this did not mean that he didn't *have* to kill her.

He sent no further message to HQ. The one they were expecting was that the girl had duly been executed. Since he could not report this, he remained silent.

In due course HQ would ask him point-blank if the order had been carried out. But delay, Clement thought, was to his and to Lesley's advantage. There would be time for HQ to find out more. And there was time for him to find out more.

It would normally have been assumed that a man and girl shut up together for weeks on end in a space station many light-years from other human beings would slide inexorably into sexual intimacy. Indeed, Lesley admitted that she had assumed this herself, and that it was partly in brash acknowledgment of the fact that she had abandoned modesty at the very beginning.

But it made a difference that Clement had very nearly killed her, and was still under orders to do so.

"I don't hate you," she told him frankly, "but I can't pretend to love you. Rationally I can make allowances, tell myself you were only doing your duty and that you're taking a big risk by letting me live. But whenever you come near me I remember that you nearly killed me, that you're still under orders to kill me."

She talked freely with him, however. And she helped him to run the tests he had to do. Having refused to execute her, Clement didn't think it did any extra harm to allow her to witness tests she wasn't supposed to see of weapons which no civilian was supposed to know about.

Mostly they tested remote-control apparatus—fuses, roboradio devices, spacemines and hyperspacemines. The weapon-testing program was designed to cover the whole field of defense and attack so that in the event of conflict standard devices could be used until effective countermeasures were discovered, and could then instantly be replaced with other devices based on different principles.

The hyperspacemine—usually abbreviated to HSM—was the newest and most secret of the weapons entrusted to Clement. Radar and other warning apparatus worked only in normal space or, modified, in hyperspace—not in both. A mine in hyperspace which could be triggered by a ship in normal space was a weapon which could be extremely effective within its limita-

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tions. Various methods of setting off HSMs were under test.

Lesley worked quickly and reliably on everything Clement gave her to do. She seemed, however, to have no particular interest in weapons.

"Boys play with guns, knives, bows and arrows, spears and swords," she said. "Girls play with dolls. I was normal. I guess you were, too."

"I guess you were, at that," Clement said thoughtfully. "Tell me . . . something's been puzzling me. Why did you pull that line at first about being the daughter of a famous senator, and not lately?"

"My father *is* a famous senator. He—"

"That's not what I mean. At first you boasted about him like a kid at school—I'm important because Daddy's important. My Daddy's more important than yours. Now you've dropped it. You haven't mentioned the famous Senator Kay for days."

She shrugged. "Don't be naïve. I knew all along you weren't supposed to let me land. Maybe the fact that there would be trouble later if you blasted me would affect you, maybe it wouldn't, but it was worth trying."

He moved behind her, put his arms round her. She was as stiff and cold as a statue. And it might be significant that since the last inquisition she had never appeared in frankly provocative dress.

He dropped his arms. "So I'm not forgiven."

"I know what you're waiting for," she retorted. "You're waiting for the next message from HQ. So am I. I've got my fingers crossed. Maybe when it arrives I'll find a gun pointed at my head again."

The message arrived an hour later.

WHY HAVE YOU NOT CONFIRMED EXECUTION? PLEASE DO SO AT ONCE.

There was a description of Lesley Kay, who *was* the daughter of Senator Kay and who was entered as a passenger on the *Pericles*. Not unexpectedly, there was as yet no news of the *Pericles*; it would have been strange if there had been. She might be having a normal flight or she might have run into trouble as Lesley claimed.

The description of Lesley Kay said she was eighteen, five feet five and a half, blonde, one hundred ten pounds. It also said she had an appendix scar.

"Have you an appendix scar?" Clement demanded.

"If I have, does it prove anything?" she asked warily. "Look, this message confirms nearly everything I told you Yet your bosses still want me executed What do I have to do to—"

"Have you an appendix scar?" Clement repeated.

She hesitated and then said: "No. They've got that wrong. I did have an appendix operation, but I had treatment to avoid a scar."

"I notice, too," said Clement quietly, "that your hair is coming up dark at the roots."

"How many blondes are real blondes?"

"I don't know. But I think HQ would check whether Lesley Kay was a real blonde or not."

"So we're on the merry-go-round again," she said wearily.

"No. The Peace Convention people are nuts. I've talked to you long enough to know you're not a nut."

"You mean . . . ?" She was incredulous.

"I mean we're waiting for the relief ship. They can figure out what to do with you."

There was more warmth between them after that. But the assumed inevitable still didn't happen. She didn't even let him touch her. Not until Clement sent a message to HQ which read:

Lesley Kay has not been executed and will not be executed by me. When I volunteered for this job I expected loneliness and a certain amount of danger and a good slice of loot in compensation. I did not volunteer as a killer of unarmed girls.

Since I guess I'm in trouble anyway I might as well start preparing my defense. I have already been exonerated for letting Miss Kay land, so my defense concerns only my failure to kill her after meeting her.

ESOs are selected very carefully. Certain qualities are looked for like honesty and integrity. Well, the kind of man you pick isn't the kind of man who can blindly obey a murder order independent of his own conclusions. My conclusion is that the woman with me is Lesley Kay and that she never had any intention of killing me. You won't care particularly if I'm wrong and she kills me, so long as the experimental program and ES47 are not affected. I do. You're not prepared to risk this station. I'm risking my life.

I realize I can't bargain with HQ, but I'm trying anyway. If the girl with me is a saboteur and has plans to destroy the station somehow, I won't have any charges to answer because I'll be dead. If she isn't, then the relief ship will be able to pick up both her and me, and no harm done. In the latter case, why not go easy on me?

He showed this message to Lesley, and she let him kiss her that night. She seemed surprised when it was he who broke the clinch, apparently finding it quite easy.

"I guess I don't understand you, Duncan," she said. "You seem to have normal instincts but supernormal self-control. If I'd been here as long as you have and a man turned up, I . . . well, you know what I mean."

"No," said Clement. "Tell me what you mean."

"Hell, I'm not asking you to make a pass at me, but I expected it all the same."

"I know."

"Don't I attract you or what?"

"You attract me all right."

"Then what? Are all ESOs like you?"

"In that respect, yes. They have to be."

"Who replaces you? Do you know?"

"A guy called Ray Lerner."

"You know him? What's he like?"

"Like me, I guess. Quiet, fairly self-sufficient. Stable.

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Possessed of a certain independence of mind."

"And undersexed?"

"Well, he's got a wife and three kids."

She was startled. "And he volunteers for a year alone in space?"

"The loot is a consideration. It'll buy him a house and pay for the education of all the kids. And by the way, I'm not undersexed either. Just patient."

"You can say that again. If it's any satisfaction to you, it's working."

"It's a great satisfaction to me."

She clearly expected more, but he dropped the subject as if it were of no importance.

Later she appeared for the first time since her early hours at the station in provocative clothes. She wore black net pajamas through which pale flesh gleamed wickedly.

Clement still didn't do anything. But he knew what was happening.

She was going to pieces in a fairly simple feminine way.

Some men could take loneliness; few women could. What worried her was not that he had no interest in her. It was that he was deeply interested, admitted it, showed it, and seemed to have no difficulty in doing nothing about it.

They had changed places. It was no longer she who was stiff and cold as a statue. Clement was a warmer statue, but still a statue.

The next message from HQ arrived opportunely. Lesley had gone to bed, locked as usual in the emergency quarters. She could not feel annoyed over this: no door in the station opened except for Clement.

The message read:

TWO STATIONS ALREADY KNOWN TO BE DESTROYED, THREE MORE DO NOT ANSWER. FOUR SHIPS ATTEMPTING TO LAND ON OTHER STATIONS DESTROYED BEFORE LANDING. IT IS CLEAR THAT THE THREATENED ALL-OUT OFFENSIVE IS ACTUALLY BEING MADE ON EXPERIMENTAL STATIONS. IRONCLAD INSTRUCTION NOW IN FORCE: ALL SHIPS SIGHTED TO BE DESTROYED WHENEVER THEY COME WITHIN RANGE.

COINCIDENCE OF LESLEY KAY'S ARRIVAL AT TIME OF THIS OFFENSIVE TOO GREAT. IT IS ACCEPTED HERE THAT PEACE CONVENTION ACTED AGAINST TEN STATIONS CONCURRENTLY. PRESENT SCORE: FIVE TO THEM, FOUR TO US, ONE—YOU—UNDECIDED.

OKAY, DO NOT KILL KAY. BUT OBTAIN FROM HER BY TORTURE IF NECESSARY ALL SHE KNOWS ABOUT PEACE CONVENTION PLANS. THEN LOCK HER IN EMERGENCY QUARTERS PENDING ARRIVAL OF RELIEF SHIP, WHICH HAS ALREADY LEFT.

"Which has already left!" Clement murmured to himself as the printer ceased chattering. She would arrive any day.

The latest message did not change the situation as far as he was concerned. He was not unduly stubborn; he took his time over making up his mind and stuck to his decision, whatever it was, until absolutely forced to change it..

The printer chattered again. Coming over was a detailed description of Lesley Kay's appendix scar. The source of information was not given.

Clement unlocked the door of Lesley's bedroom and burst in. She was asleep, but she opened her eyes as he put on the light.

"Well, well,' she said in a not displeased tone. "At last the mountain comes to Momma."

"This is a terrible thing I'm going to do, lady," he said, "but basically I'm a scientist. That means I check everything."

He tore the sheets from her. Rather unexpectedly, she was in sober, repressive pajamas. He parted the two pieces and examined the right side of her abdomen.

The smooth, pale flesh was quite unblemished.

Shocked though Clement was, it took him only a fraction of a second to reverse his attitude.

"Get up," he said curtly.

She blinked at him as if wondering if she was dreaming. He pulled her roughly to her feet.

"Up to now," he said grimly, "you were a pretty girl I liked, and might have gone on liking even if you were mixed up somehow with the Peace Convention. Now you're an enemy with information which I've got to have. What are the plans to destroy this station?"

"I don't know what you're—"

He swore. He would have liked to hit her brutally to show her that she wasn't playing games any more, but couldn't do it. He knew he was capable of killing her, yet he was not capable of brutality.

He dragged her through to the air lock, still in her pajamas. There he pointed to her spacesuit, laid ready for her.

"Get into that," he said curtly.

"What for?"

"Because if you don't I'll knock you unconscious and put you in it."

"I don't believe you can go through with this, Duncan," she said steadily.

He swore again. "Will you never realize that there's more in life than playing games? Get into that suit."

"Why? What are you going to do?"

"Kill you if you don't tell me every thing you know. Your friends have killed five ESOs already, do you know that? You're trying to kill either me or Ray Lerner, I don't know which—"

"Why Ray Lerner?" she asked sharply, caught off balance.

"Brave idealists like you are often prepared to kill

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for the greatest good of the greatest number, as you see it, but you usually fix things so that you yourselves don't have to die as well. Get into that suit."

"No."

He drew his arm back. She read in his eyes his complete determination, and turned hurriedly to the suit. Two minutes later she was encased in it except for the helmet.

"Right," said Clement harshly. "You're going outside. Conscious or unconscious, I don't care. You have air for exactly twenty minutes. That's not nearly enough time for you to reach the lifeboat. If you don't come back in, you die. And you don't get back in here unless you're prepared to tell me everything you know."

"You won't go through with it. I know you. You're not a killer."

"But you are. And even a non-killer can kill in self-defense. That's what I'm doing now."

"You won't die. You can't die, because I—" She stopped.

"Go on."

But she remained silent.

So he fastened her helmet. Protected by her suit, she tried to struggle, but he showed her that his strength and agility more than made up for the protection her suit afforded her. He pushed her into the air lock and operated the outer doors.

Then he sat down and waited.

He didn't have to wait long. Within three minutes she was tapping on the inside door.

Clement let her in, but the moment her helmet was off he said grimly: "If you're stalling, you go right out again. With no more air."

Incredibly, she was smiling. "Help me to get out of this suit."

He did so. Her attitude puzzled him. He wasn't even sure what it was, not having the key to figure it out.

The suit removed, she said: "You startled me. I didn't have a chance to think. I didn't realize quite what . . ."

She rolled down the elastic of her pants. Once, twice, she brushed the flesh of her belly roughly with the side of her hand. Then she took it away.

Clearly marked in red was exactly the scar which had been described in the last message.

Clement stared at it. Already the red marks were beginning to fade. Yet there was no trickery. It was impossible.

"I guess I have to say I'm sorry again," he said quietly. "You're Lesley Kay all right."

"Yes. You're really satisfied this time?" She fixed her clothes.

He nodded.

"Good," she said with relief, "because I thought I'd left it too late. I've been hoping for days I wouldn't have to tell you a thing. But I knew all along I'd have to."

Clement was not given to demonstration. He waited.

"You accused me of playing games," she said. "That was fair. You might have called me a silly kid, too. I *told* you I'm seventeen. Back on Earth the Peace Convention attitude sounded utterly right, the whole thing seemed like a great adventure. I was ripe to be used, and they used me. I still felt the same thrill on the *Pericles*, and when the job their engineer had done on the drive worked exactly as they said it would, when they said it would, I felt I was part of a great invincible shining machine working for the good of humanity. When I made my big appearance here in my undies I was partly responding to a dare and partly acting my thrilling seductive scene.

"But you were . . . well, you weren't a kid. You weren't playing any games. You were real. Gradually the thing ceased to be a great adventure, and all I'd believed so easily began to wear a little thin, and I saw there was another side to it, and you told me about Ray Lerner and his wife and three kids . . ."

Clement remained silent, knowing she would have to fill the vacuum with words.

"And then when the whole thing had collapsed anyway," she said, suddenly near to tears, "you told me how brave idealists were often prepared to kill, but usually fixed things so that they didn't have to die themselves. That made me feel about one centimeter high, and there was no game any more."

The relief ship arrived two days later. Captain Walters came down himself, alone; the situation was awkward and he didn't shirk handling it himself.

He was relieved to find Clement alone in the main control room and apparently quite rational. "Where's the girl?" Walters demanded.

Clement ignored the question. "Captain, you've got a lot of responsibility. I want you on my side."

"I'm making no promises, Clement."

"Maybe you have to, captain."

"How do you mean?"

"There's a bomb on this planetoid which will blow the whole station to pieces in about three months' time —unless you do a deal."

"I don't have to do a deal. I'll find the bomb."

Clement gestured. "Out there, captain?"

Walters was silenced. The planetoid consisted of holes. Big holes, small holes. Holes that went straight down, holes that ran horizontal, holes than ran upwards. Holes a foot deep, twenty feet deep, fifty yards long. A bomb pushed a mere arm's length into a cavity might never be seen again. A bomb pushed into a gently-sloping cleft might slide down a hundred feet and would certainly never be seen again.

"We have detectors," Walters said at last.

"You have my personal word for it that all detectors you have available will set off the bomb. And you can't do a thing about the three-month fuse. It's an organic break-down fuse, sealed off and heat-insulated, natural-

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ly, and anything you might try out on the organic fuse will set off the other fuses. But the bomb, if you can find it, can be safely picked up and carried anywhere you want it."

"Hell, Clement, what's this you're giving me? Where's the girl? Dead? Alive? Hurt? Gone?"

Clement answered indirectly. "I want to do a deal, captain. The girl for the bomb."

"You know where it is?"

"No, but she does."

"It's not on the lifeboat?"

"No. It's hidden, set to go off in three months, by which time there's a chance, or there would have been a chance, that the explosion would be put down to accident—a slight error on Ray Lerner's part."

"We'll still find out from the girl—"

"No, captain, you won't. Lesley's been treated so that truth drugs won't work in the next six months, they'll simply destroy her brain. And . . . other methods don't work. I tried them."

"You mean torture?" said the captain bluntly.

"By telling her about Ray Lerner and his wife and children," said Clement blandly. "She didn't mind killing an ESO she knew nothing about. But once she knew about Ray Lerner, she broke down. She's a good kid—and she *is* Senator Kay's daughter. His only daughter."

That registered with Walters. He rallied, however. "Nevertheless, she didn't tell you where she'd placed the bomb?"

"No. She wants an amnesty. You can't blame her, can you? She'll finger the bomb if you promise—

"It's impossible, Clement."

"Then the station goes up in three months," said Clement regretfully. "No use looking for the bomb, as a glance at the terrain will show you. She could have hidden a thousand bombs. Besides, if you use detectors, it goes off—"

"You're in this with her," Walters said accusingly. "You put her up to it. The amnesty business, I mean."

"Having learned all she knows—except where the bomb is. My report on the Peace Convention should be very useful, captain. She hasn't given names, but there's plenty about plans and methods."

"I want to see her."

"Listen, captain. She's seventeen. Remember the kind of things we did when we were seventeen?"

"I can't do what you're asking."

"You'd rather the bomb was left where it is than have her show you?"

Walters breathed hard. "I'm warning you, Clement, if you do get what you want . . . The girl may go free, but we'll throw the book at you."

Lesley was subdued on the way back to Earth. "I still feel one centimeter high," she said. "And shrinking. How could I be so wrong, when I was so *sure*—"

"What's a murder more or less when ideals are at stake?" said Clement tolerantly, looking down at her.

"I can't understand how you . . . why you—"

"Why I now exhibit normal interest in you, even to the point of possibly having to marry you? I don't understand it either. But I'm going to kiss you again. Nobody will ever believe I resisted so long."

A little later, Clement kept an appointment in the captain's cabin with Walters.

"I'm writing my report," Walters said stiffly. "I want to know if there's anything you have to say."

"Yes," said Clement, "I want to tell you why what happened was almost inevitable."

"Huh?"

"I want to point out that the Convention's sabotage efforts succeeded to the extent that they did because of the method of selection of ESOs. Among other things."

Walters' eyes narrowed. "I'm listening. If you can make your point, Clement, it may help."

"ESOs are solitary, independent men. They may not be geniuses, but they're used to making up their own minds. There's nobody to apply to. All the decisions they make for a year, big and little, some affecting the whole testing program, are their own. They're selected to work autonomously."

"Right," Walters admitted.

"HQ made its big mistake instructing ESOs to destroy any ship sighted. Hell, we always make up our own minds. We're chosen for that reason. We're not privates who don't move until the corporal tells us, having been told by the sergeant, having been told by the lieutenant, having been told by the captain, who perhaps was permitted to think for himself. Leave us to decide and we'll make better decisions, because we're that sort of men. The only thing we can't handle is millstones on our minds.

"When I sighted a lifeboat, I knew orders were to destroy it. But was that a good order? ESOs are *instructed* to question orders, captain. If the testing program mapped out for them doesn't seem right, they're supposed to change it. They're trusted to act independently if and when the greatest, most significant event in human history happens—the first encounter with another comparable race. It's a shocking mistake not to trust them with something much less . . . When Lesley's ship was coming in, I guess I'd have blown it up if I hadn't been ordered to do it and at the same time ordered to question all orders. Still with me?"

Walters grunted. "Maybe we will make a change."

"I think you should, captain."

"You'll get off, Clement," Walters said grudgingly.

"I think so, too."

"You'll get off because of something you don't even remember. In your training, in every ESO's training, you're told to fire a weapon which, if what you've been told is correct, will explode before it gains momentum. If you do as you're told, you're out."

"I *had* forgotten that," Clement admitted." ■

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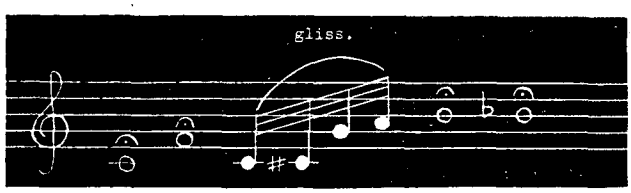
TERRITORY

**Sometimes it takes a really hard,
tough and ruthless man
to see that the best way to make friends
with someone is to slug him flat,
kick him while he's down,
and then shake hands . . .**

by POUL ANDERSON

ILLUSTRATED BY LEO SUMMERS



Joyce Davisson awoke is if she had been stabbed.

The whistle came again, strong enough to penetrate mortar and metal and insulation, on into her eardrums. She sat up in the dark with a gasp of recognition. When last she heard that wildcat wail, it was in the Chabanda, and it meant that two bands were hunting each other. But then she had been safely aloft in a flitter, armed men on either side of her and a grave Ancient for guide. What she saw and heard came to her amplified by instruments that scanned the ice desert glittering beneath. Those tiger-striped warriors who slew and died were only figures on a screen. She had felt sorry for them, yet somehow they were not quite real: individuals only, whom she had never met, atoms that perished because their world was perishing. Her concern was with the whole.

Now the whistle was against her station.

It couldn't be!

An explosion went *crump.* She heard small things rattle on her desktop and felt her bed shaken. Suddenly the glissandi were louder in her head, and a snarl

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of drumtaps accompanied them, a banging on metal and crashing as objects were knocked off shelves. The attackers must have blown down the door of the machine section and swarmed through. Only where could they have gotten the gunpowder?

Where but in Kusulongo the City?

That meant the Ancients had decided the humans were better killed. The fear of death went through Joyce in a wave. It passed on, leaving bewilderment and pain, as if she were a child struck for no reason. Why had they done this to her, who came for nothing but to help them?

Feet pounded in the hall just outside the terrestrialized section of the dome. The mission's native staff had roused and were coming out of their quarters with weapons to hand. She heard savage yells. Then, further off among the machines, combat broke loose. Swords clattered, tomahawks cracked on bone, the pistol she had given Uulobu spoke with an angry snap. But her gang couldn't hold out long. The attackers had to be Shanga, from the camp in the oasis just under Kusulongo the Mountain. No other clan was near, and the Ancients themselves never fought aggressively. But there were hundreds of male Shanga in the oasis, while the mission had scarcely two dozen trustworthy t'Kelans.

Heavily armored against exterior conditions, the human area would not be entered as easily as the outside door of the machine section had been gotten down. But once the walls were cracked—

Joyce bounded to her feet. One hand passed by the main switchplate on its way to her gear rack, and the lights came on. The narrow, cluttered room, study as well as sleeping place, looked somehow distorted in that white glow. *Because I'm scared,* she realized. *I'm caught in a living nightmare.* Nerve and muscle carried on without her mind. She leaped into the formfitting Long John and the heavy fabricord suit. Drawing the skin-thin gloves over her hands, she connected their wiring to the electric net woven into the main outfit. Now: kerofoam-soled boots; air renewal tank and powerpack on the back; pistol and bandolier; pouched belt of iron rations; minicom in breast pocket; vitryl helmet snugged down on the shoulders but face plate left open for the time being.

Check all fasteners, air system, heat system, everything. The outdoors is lethal on t'Kela. The temperature, on this summer night in the middle latitudes, is about sixty below zero Celsius. The partial pressure of nitrogen will induce narcosis, the ammonia will burn out your lungs. There is no water vapor that your senses can detect; the air will suck you dry. None of these factors differ enough from Earth to kill you instantly —no, aided by an oxygen content barely sufficient to maintain your life, you will savor the process for minutes before you even lose consciousness.

And the Shanga out there, now busily killing your native assistants, have gunpowder to break down these walls.

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hell is going on here for fumblydiddles? I thought, me, you had anyhows the trust of those natives!"

"The others," Joyce choked. "Come on, let's get together with them."

Van Rijn nodded curtly, so that his several chins quivered, and let her take the lead. Personal rooms in the human section faced the same corridor, each with a door opening on that as well as on its two neighbors. Joyce's room happened to be at the end of the row, with the machine storage section on its farther side. Unmarried and fond of privacy, she had chosen that arrangement when she first came here. The clubroom was at the hall's other terminus, around the curve of the dome. As she emerged from her quarters, Joyce saw door after door gaping open. The only ones still closed belonged to chambers which nobody occupied, extras built in the anticipation of outside visitors like van Rijn's party. So everyone else had already gotten into their suits and down to the clubroom, the fixed emergency rendezvous. She broke into a run. Van Rijn's ponderous jogtrot made a small earthquake behind her. Gravity on t'Kela was about the same as on Earth or Esperance.

The only thing that's the same, Joyce thought wildly. For an instant the recollection of her home on the green planet of the star called Pax—a field billowing with grain, remote blue mountains, the flag of the sovereign world flying red and gold against a fleecy sky, and that

ave dream which had built the Commonalty—nearly nded her.

It roared at her back. The floor heaved underfoot. she fell, the boom came again, and yet again. The d explosion pierced through. A hammerblow of cussion followed.

triking the floor, she rolled over. Her head rattled m side to side of her helmet. The taste of blood mixed h smoke in her mouth. She looked back down the ridor through ragged darknesses that came and went ore her eyes. The wall at the end, next to her own m, was split and broken. Wild shadowy figures moved he gloom beyond the twisted structural members.

"They blew it open," she said stupidly.

Close your helmet," van Rijn barked. He had al- ly clashed his own face plate to. The amplifier ught her his gravelly tones, but a dullness would let them through to her brain.

They blew it open," she repeated. The thing seemed strange to be real.

native leaped into the breach. He could stand Terrial air and temperature for a while if he held his ath. And t'Kelan atmosphere, driven by a higher sure, was already streaming past him. The stocky, ed figure poised in a tension like that of the strung he aimed. Huge slit-pupilled eyes glared in the light n the fluoros.

n Esperancian technician came running around the l of the corridor. "Joyce!" he cried. "Freeman van ! Where—" The bow twanged. A barbed arrowhead ripped his suit. An instant afterward the air seemed full of arrows, darts, spears, hurled from the murk. Van Rijn threw himself across Joyce. The technician spun on his heel and fled.

Van Rijn's well-worn personal blaster jumped into his fist. He fired from his prone position. The furry shape in the breach tumbled backward. The shadows behind withdrew from sight. But the yell and clatter went on out there.

A first ammoniacal whiff stung Joyce's nostrils. "Pox and pestilence," van Rijn growled. "You like maybe to breathe that dragon belch?" He rose to his knees and closed her face plate. His little black close-set eyes regarded her narrowly. "So, stunned, makes that the way of it? Well, hokay, you is a pretty girl with a nice figure and stuff even if you should not cut your hair so short. Waste not, want not. I rescue you, ha?"

He dragged her across one shoulder, got up, and backed wheezily along the hall, his blaster covering the direction of the hole. "Ugh, ugh," he muttered, "this is not a job for a poor old fat man who should be at home in his nice office on Earth with a cigar and maybe a wee glass Genever. The more so when those misbegotten snouthearts he must use for help will rob him blind, *ja,* unscrew his eyeballs they will, so soon as he isn't looking. But all the factors at all the trading posts are

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such gruntbrains that poor Nicholas van Rijn must come out his own selfs, a hundred lightyears in the direction of Orion's bellybutton he must come, and look for new trading possibilities. Else the wolves-with-rabies competition tears his Solar Spice & Liquors Company in shreds and leaves him prostitute in his old age . . . Ah, here we is. Downsy-daisy."

Joyce shook her head as he eased her to the floor. Full awareness had come back, and her knees didn't wobble much. The clubroom door was in front of her. She pushed the switch. The barrier didn't move. "Locked," she said.

Van Rijn pounded till it shivered. "Open up!" he bellowed. "Thunder and thighbones, what is this farce? Open up!"

A native raced around the curve of the hall. Van Rijn turned. Joyce shoved his blaster aside. "No, that's Uulobu." The t'Kelan must have exhausted his pistol and thrown it away, for a tomahawk now dripped in his hand. Three other autochthones bounded after him, swords and hatchets aloft. Their kilts were decorated with the circle-and-square insignia of the Shanga clan. "Get them!"

Van Rijn's blaster spat fire. One of the invaders flopped over. The others whirled to escape. Uulobu yowled and threw his tomahawk. The keen obsidian edge struck a Shanga and knocked him down, bleeding. Uulobu yanked the cord that ran between his weapon and wrist, retrieved the ax, and threw it again to finish the job.

Van Rijn returned to the door. "You termite-bitten cowards, let us in!" As his language got bluer, Joyce realized what must have happened. She pounded his back with her fists, much as he was pounding the door, until he stopped and looked around.

"They wouldn't abandon us," Joyce said. "But they must think we've been killed. When Carlos saw us, back there in the hall, we were both lying on the floor, and there were so many missiles—They aren't in the clubroom any longer. They locked the door to delay the enemy while they took a different way to the spaceships."

"Ah, *ja, ja,* must be. But what do we do now? Blast through the door to follow?"

Uulobu spoke in the guttural language of the Kusulongo region. "All of us are slain or fled, sky-female. No more battle. The noise you hear now is the Shanga plundering. If they find us, they will fill us with arrows. Two guns cannot stop that. But I think if we go back among the iron-that-moves, we can slip out that way and around the dome."

"What's he besputtering about?" van Rijn asked.

Joyce translated. "I think he's right," she added. "Our best chance is to leave through the machine section. It seems deserted for the time being. But we'd better hurry."

"So. Let this pussycat fellow go ahead, then. You stay by me and cover my back, *nie?*"

They trotted the way they had come. Hoarfrost whitened the walls and made the floor slippery, as water vapor condensed in the t'Kelan cold. The breach into the unlighted machine section gaped like a black mouth. Remotely through walls, Joyce heard ripping, smashing, exultant shouts. The work of years was going to pieces around her. *Why?* she asked in pain, and got no answer.

Uulobu's eyes, more adaptable to dark than any human's, probed among bulky shapes as they entered the storage area. Vehicles were parked here: four groundcars and as many flitters. In addition, this long chamber housed the specialized equipment of the studies the Esperancians had made, seeking a way to save the planet. Most lay in wreckage on the floor.

An oblong of dim light, up ahead, was the doorway to outside. Joyce groped forward. Her boot struck something, a fallen instrument. It clanked against something else.

There came a yammer of challenge. The entrance filled with a dozen shapes. They whipped through and lost themselves among shadows and machines before van Rijn could fire. Uulobu hefted his tomahawk and drew his knife. "Now we must fight for our passage," he said unregretfully.

"Cha-a-a-arge!" Van Rijn led the way at a run. Several t'Kelans closed in on him. Metal and polished stone whirled in the murk. The Earthman's blaster flared. A native screamed. Another native got hold of the gun arm and dragged it downward. Van Rijn tried to shake him loose. The being hung on, though the human clubbed him back and forth against his fellows.

Uulobu joined the ruckuss, stabbing and hacking with carnivore glee. Joyce could not do less. She had her own pistol out, a slug-thrower. Something bumped into the muzzle. Fangs and eyes gleamed at her in what light there was. A short spear poised, fully able to pierce her suit. Even so, she had never done anything harder than to pull the trigger. The crack of the gun resounded in her own skull.

Then for a while it was jostling, scrabbling, firing, falling and wrestling lunacy. Now and again Joyce recognized Uulobu's screecn, the battle cry of his Avongo clan. Van Rijn's voice trumpeted, "St. Dismas help us! Down with mangy dogs!" Suddenly it was over. The guns had been too much. She lay on the floor, struggling for breath, and heard the last few Shanga run out. Somewhere a wounded warrior groaned, until Uulobu cut his throat.

"Up with you," van Rijn ordered between puffs. "We got no time for making rings around the rosies."

Uulobu helped her rise. He was too short to lean on very well, but van Rijn offered her an arm. They staggered out the door, into the night.

There was no compound here, only the dome and then t'Kela itself. Overhead glittered unfamiliar constellations. The larger moon was aloft, nearly full, throwing dim coppery light on the ground. West and

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south stretched a rolling plain, thinly begrown with shrubs not unlike Terrestrial sagebrush in appearance: low, wiry, silvery-leaved. Due north rose the sheer black wall of Kusulongo the Mountain, jagged against the Milky Way. The city carved from its top could only be seen as a glimpse of towers like teeth. Some kilometers eastward, at its foot, ran the sacred Mangivolo River. Joyce could see a red flash of moonlight on liquid ammonia. The trees of that oasis where the Shanga were camped made a blot of shadow. The hills that marched northward from Kusulongo gleamed with ice, an unreal sheen.

"Hurry," van Rijn grated. "If the other peoples think we are dead, they will raise ship more fast than they can."

His party rounded the dome at the reeling pace of exhaustion. Two tapered cylinders shimmered under the moon, the mission's big cargo vessel and the luxury yacht which had brought van Rijn and his assistants from Earth. A couple of dead Shanga lay nearby. The night wind ruffled their fur. It had been a fight to reach safety here. Now the ramps were retracted and the airlocks shut. As van Rijn neared, the whine of engines shivered forth.

"Hey!" he roared. "You clabberbrains, wait for me!"

The yacht took off first, hitting the sky like a thunderbolt. The backwash of air bowled van Rijn over. Then the Esperancian craft got under weigh. The edge of her drive field caught van Rijn, picked him up and threw him several meters. He landed with a crash and lay quite still.

Joyce hurried to him. "Are you all right?" she choked. He was a detestable old oaf, but the horror of being marooned altogether alone seized upon her.

"Oo-oo-oo," he groaned. "St. Dismas, I was going to put a new stained glass window in your chapel at home. Now I think I will kick in the ones you have got."

Joyce glanced upward. The spaceships flashed for an instant like rising stars, and vanished. "They didn't see us," she said numbly.

"Tell me more," van Rijn snorted.

Uulobu joined them. "The Shanga will have heard," he said. "They will come out here to make sure, and find us. We must escape."

Van Rijn didn't need that translated. Shaking himself gingerly, as if afraid something would drop off, he crawled to his feet and lurched back toward the dome. "We get a flitter, *nie*?" he said.

"The groundcars are stocked for a much longer period," Joyce answered. "And we'll have to survive until someone comes back here."

"With the pest-riddled planeteezers chasing us all the while," van Rijn muttered. "Joy forever, unconfined!"

"We go west, we find my people," Uulobu said. "I do not know where the Avongo are, but other clans of the Rokulela Horde must surely be out between the Narrow Land and the Barrens."

They entered the machine section. Joyce stumbled on a body and shuddered. Had she killed that being herself?

The groundcars were long and square-built; the rear four of the eight wheels ran on treads. The accumulators were fully charged, energy reserve enough to drive several thousand rough kilometers and maintain Earth-type conditions inside for a year. There were air recyclers and sufficient food to keep two humans going at least four months. Six bunks, cooking and sanitary facilities, maps, navigation equipment, a radio transceiver, spare parts for survival gear—everything was there. It had to be, when you traveled on a planet like this.

Van Rijn heaved his bulk through the door, which was not locked, and settled himself in the driver's seat. Joyce collapsed beside him. Uulobu entered with uneasy eyes and quivering whiskers. Only the Ancients, among t'Kelans, liked riding inside a vehicle. That was no problem, though, Joyce recalled dully. On field trips, once you had established a terrestroid environment within, your guides and guards rode on top of the car, talking with you by intercom. Thus many kilometers had been covered, and much had been learned, and the plans had been drawn that would save a world . . . and now!

Van Rijn's ham hands moved deftly over the controls. "In my company we use Landmasters," he said. "I like not much these Globetrotters. But sometimes our boys have to, um, borrow one from the competition, so we know how to—Ah." The engine purred to life. He moved out the door, riding the field drive at its one-meter ceiling instead of using the noisier wheels.

But he could have saved his trouble. Other doors in the dome were spewing forth Shanga. There must be a hundred of them, Joyce thought. Van Rijn's lips skinned back from his teeth. "You want to play happy fun games yet, ha?" He switched on the headlights.

A warrior was caught in the glare, dazzled by it so that he stood motionless, etched against blackness. Joyce's eyes went over him, back and forth, as if something visible could explain why he had turned on her. He was typical t'Kelan of this locality; races varied elsewhere, as on most planets, but no more than among humans.

The stout form was about one hundred fifty centimeters tall, heavily steatopygous to store as much liquid as the drying land afforded. Hands and feet were nearly manlike, except for having thick blue nails and only four digits apiece. The fur that covered the whole body was a vivid orange, striped with black, a triangle of white on the chest. The head was round, with pointed ears and enormous yellow cat-eyes, a scarlet ruff on top, two fleshy tendrils on the forehead, a single nostril crossing the broad nose, a lipless mouth full of sharp white teeth framed in restless cilia. This warrior carried a sword—the bladelike horn of a *gondyanga* plus a wooden handle—and a round shield painted in the colors of the Yagola Horde to which the Shanga clan belonged.

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"Beep, beep!" van Rijn said. He gunned the car forward.

The warrior sprang aside, barely in time. Others tried to attack. Joyce glimpsed one with a bone piston whistle in his mouth. The Yagola never used formal battlecries, but advanced to music. A couple of spears clattered against the car sides. Then van Rijn was through, bounding away at a hundred KPH with a comet's tail of dust behind.

"Where we go now?" he demanded. "To yonder town on the mountain? You said they was local big cheeses."

"The Ancients? No!" Joyce stiffened. "They must be the ones who caused this."

"Ha? Why so?"

"I don't know, I don't know. They were so helpful before . . . But it has to be them. They incited—No one else could have. W-we never made any enemies among the clans. As soon as we had their biochemistry figured out, we synthesized medicines and . . . and helped them —" Joyce found suddenly that she could cry. She leaned her helmet in her hands and let go all emotional holds.

"There, there, everything's hunky-dunky," van Rijn said. He patted her shoulder. "You been a brave girl, as well as pretty. Go on, now, relax, have fun."

T'Kela rotated once in thirty hours and some minutes, with eight degrees of axial tilt. Considerable night remained when the car stopped, a hundred kilometers from Kusulongo, and the escapers made camp. Uulobu took a sleeping bag outside while the others Earth-conditioned the interior, shucked their suits, and crawled into bunks. Not even van Rijn's snores kept Joyce awake.

Dawn roused her. The red sun climbed from the east with a glow like dying coals. Though its apparent diameter was nearly half again that of Sol seen from Earth or Pax from Esperance, the light was dull to human eyes, shadows lay thick in every dip and gash and the horizon was lost in darkness. The sky was deep purple, cloudless, but filled to the south with the yellow plumes of a dust storm. Closer by, the plain stretched bare, save for sparse gray vegetation, strewn boulders, a coldly shimmering ice field not far northward. One scavenger fowl wheeled overhead on leathery-feathered wings.

Joyce sat up. Her whole body ached. Remembering what had happened made such an emptiness within that she hardly noticed. She wanted to roll over in the blankets, bury her head, and sleep again. Sleep till rescue came, if it ever did.

She made herself rise, go into the bath cubicle, wash and change into slacks and blouse. With refreshment came hunger. She returned to the main body of the car and began work at the cooker.

The smell of coffee wakened van Rijn. "Ahhh!" Whalelike in the Long John he hadn't bothered to remove, he wallowed from his bunk and snatched after a cup. "Good girl." He sniffed suspiciously. "But no brandy in it? After our troubles, we need brandy."

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"No liquor here," she snapped.

"*What?*" For a space the merchant could only goggle at her. His jowls turned puce. His mustaches quivered. "Nothings to drink?" he strangled. "Why, why, why, this is extrarageous. Who's responsible? By damn, I see to it he's blacklisted from here to Polaris!"

"We have coffee, tea, powdered milk and fruit juices," Joyce said. "We get water from the ice outside. The chemical unit removes ammonia and other impurities. One does not take up storage space out in the field with liquor, Freeman van Rijn."

"One does if one is civilized. Let me see your food stocks." He rummaged in the nearest locker. "Dried meat, dried vegetables, dried— Death and destruction!" he wailed. "Not so much as one jar caviar? You want me to crumble away?"

"You might give thanks you're alive."

"Not under this condition . . . Well, I see somebody had one brain cell still functional and laid in some cigarettes." Van Rijn grabbed a handful and crumbled them into a briar pipe he had stuffed in his bosom. He lit it. Joyce caught a whiff, gagged, and returned to work at the cooker, banging the utensils about with more ferocity than was needful.

Seated at the folding table next to one of the broad windows, van Rijn crammed porridge down his gape and peered out at the dim landscape. "Whoof, what a place. Like hell with the furnaces on the fritz. How long you been here, anyways?"

"Myself, about a year, as a biotechnician." She decided it was best to humor him. "Of course, the Esperancian mission has been operating for several years."

"*Ja,* that I know. Though I am not sure just how. I was only here a couple of days, you remember, before the trouble started. And any planet is so big and complicated a thing, takes long to understand it even a little. Besides, I had some other work along I must finish before investigating the situation here."

"I admit being puzzled why you came. You deal in spices and things, don't you? But there's nothing here that a human would like. We could digest some of the proteins and other biological compounds—they aren't all poisonous to us—but they lack things we need, like certain amino acids, and they taste awful."

"My company trades with nonhumans, too," van Rijn explained. "Not long ago, my research staff at home came upon the original scientific reports, from the expedition who found this planet fifteen years ago. This galaxy is so big no one can keep track of everything while it happens. Always we are behind. But anyhows, was mention of some wine that the natives grow."

"Yes, *kungu.* Most of the clans in this hemisphere make it. They raise the berries along with some other plants that provide fiber. Not that they're farmers. A carnivorous race, nomadic except for the Ancients. But they'll seed some ground and come back in time to harvest it."

"Indeed. Well, as you know, the first explorers here was from Throra, which is a pretty similar planet to this only not so ugh. They thought the *kungu* was delicious. They even wanted to take seeds home, but found because of ecology and stuffs, the plant will only grow on this world. Ah-ha, thought Nicholas van Rijn, a chance maybe to build up a very nice little trade with Throra. So because of not having nobody worth trusting that was on Earth to be sent here, I came in my personals to see. Oh, how bitter to be so lonely!" Van Rijn's mouth drooped in an attempt at pathos. One hairy hand stole across the table and closed on Joyce's.

"Here comes Uulobu," she exclaimed, pulling free and jumping to her feet. *In the very nick of time, bless both his hearts!*

The t'Kelan loped swiftly across the plain. A small animal that he had killed was slung across his shoulders. He was clad differently from the Shanga: in the necklace of fossil shells and the loosely woven blue kilt of his own Avongo clan and Rokulela Horde. A leather pouch at his waist had been filled with liquid.

"I see he found an ammonia well," Joyce chattered, brightly and somewhat frantically, for van Rijn was edging around the table toward her. "That's what they have those tendrils for, did you know? Sensitive to any trace of ammonia vapor. This world is so dry. Lots of frozen water, of course. You find ice everywhere you go on the planet. Very often hundreds of square kilometers at a stretch. You see, the maximum temperature here is forty below zero Celsius. But ice doesn't do the indigenous life any good. In fact, it's one of the things that are killing this world."

Van Rijn grumped and moved to the window. Uulobu reached the car and said into the intercom: "Sky-female, I have found spoor of hunters passing by, headed west toward the Lubambaru. They can only be Rokulela. I think we can find them without great trouble. Also I have quenched my thirst and gotten meat for my hunger. Now I must offer the Real Ones a share."

"Yes, do so for all of us," Joyce answered.

Uulobu began gathering sticks for a fire. "What he say?" van Rijn asked. When Joyce had translated: "So. What use to us, making league with savages out here? We only need to wait for rescue."

"If it comes," Joyce said. She shivered. "When they hear about this at Esperance, they'll send an expedition to try and learn what went wrong. But not knowing we're alive, they may not hurry it enough."

"*My* people will," van Rijn assured her. "The Polesotechnic League looks after its own, by damn. So soon as word gets to Earth, a warship comes for full investigation. Inside a month."

"Oh, wonderful," Joyce breathed. She went limp and sat down again.

Van Rijn scowled. "Natural," he ruminated, "they cannot search a whole planet. They will know I was at

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that bestinkered Kusulongo place, and land there. I suppose those Oldsters or Seniles or whatever you call them is sophisticated enough by now in interstellar matters to fob the crew off with some story, if we are not nearby to make contact. So . . . we must remain in their area, in radio range. And radio range has to be pretty close on a red dwarf's planet, where ionosphere characteristicals are poor. But close to our enemies we cannot come so well, if they are whooping after us the whole time. They can dig traps or throw crude bombs or something —one way or other, they can kill us even in this car. Ergo, we must establish ourselves as too strong to attack, in the very neighborhood of Kusulongo. This means we need allies. So you have right, we must certain go along to your friend's peoples."

"But you can't make them fight their own race!" Joyce protested.

Van Rijn twirled his mustache. "Can't I just?" he grinned.

"I mean . . . I don't know how, in any practical sense . . . but even if you could, it would be wrong."

"Um-m-m." He regarded her for a while. "You Esperancers is idealists, I hear. Your ancestors settled your planet for a utopian community, and you is still doing good for everybody even at this low date, *nie?* Your mission to help this planet here was for no profit, except it makes you feel good—"

"And as a matter of foreign policy," Joyce admitted, under the honesty fetish of her culture. "By assisting other races, we gain their good will and persuade them, a little, to look at things our way. If Esperance has enough such friends, we'll be strong and influential without having to maintain armed services."

"From what I see, I doubt very much you ever make nice little vestrymen out of these t'Kelans."

"Well . . . true . . . they *are* out-and-out carnivores. But then, man started as a carnivorous primate, didn't he? And the t'Kelans in this area did achieve an agricultural civilization once, thousands of years ago. That is, grain was raised to feed meat animals. Kusulongo the City is the last remnant. The ice age wiped it out otherwise, leaving savagery—barbarism at most. But given improved conditions, I'm sure the autochthones could recreate it. They'll never have unified nations or anything, as we understand such things. They aren't gregarious enough. But they could develop a world order and adopt machine technology."

"Except, from what you tell me, those snakes squatting on top of the mountain don't want that."

Joyce paused only briefly to wonder how a snake could squat, before she nodded. "I guess so. Though I can't understand why. The Ancients were so helpful at first."

"Means they need to have some sense beaten into their skullbones. Hokay, so for the sake of t'Kela's long-range good, we arrange to do the beating, you and I."

"Well . . . maybe . . . but still—"

Van Rijn patted her head. "You just leave the philosophizings to me, little girl," he said smugly. "You only got to cook and look beautiful."

Uulobu had lit his fire and thrown the eyeballs of his kill onto it. His chant to his gods wailed eerily through the car wall. Van Rijn clicked his tongue. "Not so promising materials, that," he said. "You civilize them if you can. I am content to get home unpunctured by very sharp-looking spears, me." He rekindled his pipe and sat down beside her. "To do this, I must understand the situation. Suppose you explain. Some I have heard before, but no harm to repeat." He patted her knee. "I can always admire your lips and things while you talk."

Joyce got up for another cup of coffee and reseated herself at a greater distance. She forced an impersonal tone:

"Well, to begin with, this is a very unusual planet. Not physically. I mean, there's nothing strange about a type M dwarf star having a planet at a distance of half an A.U., with a mass about forty per cent greater than Earth's."

"So much? Must be low density, then. Metal-poor."

"Yes. The sun is extremely old. Fewer heavy atoms were available at the time it formed with its planets. T'Kela's overall specific gravity is only 4.4. It does have some iron and copper, of course . . . As I'm sure you know, life gets started slowly on such worlds. Their suns emit so little ultraviolet, even in flare periods, that the primordial organic materials aren't energized to interact very fast. Nevertheless, life does start eventually, in oceans of liquid ammonia."

"*Ja.* And usual goes on to develop photosynthesis using ammonia and carbon dioxide, to make carbohydrates and the nitrogen that the animals breathe." Van Rijn tapped his sloping forehead. "So much I have even in this dumb old bell. But why does evolution go different now and then, like on here and Throra?"

"Nobody knows for sure. Some catalytic agent, perhaps. In any event, even at low temperatures like these, all the water isn't solid. A certain amount is present in the oceans, as part of the ammonium hydroxide molecule. T'Kelan or Throran plant cells have an analogue of chlorophyl, which does the same job: using gaseous carbon dioxide and 'dissolved' water to get carbohydrates and free oxygen. The animals reverse the process, much as they do on Earth. But the water they release isn't exhaled. It remains in their tissues, loosely held by a specialized molecule. When an organism dies and decays, this water is taken up by plants again. In other words, H_2O here acts very much like nitrogenous organic material on our kind of planets."

"But the oxygen the plants give off, it attacks ammonia."

"Yes. The process is slow, especially since solid ammonia is denser than the liquid phase. It sinks to the bottom of lakes and oceans, which protects it from the air. Nevertheless, there is a gradual conversion. Through a

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series of steps, ammonia and oxygen yield free nitrogen and water. The water freezes out. The seas shrink, the air becomes poorer in oxygen, the desert areas grow."

"This I know from Throra. But there a balance was struck. Nitrogen-fixing bacteria evolved and the drying out was halted, a billion years ago. So they told me once."

"Throra was lucky. It's a somewhat bigger planet than t'Kela, isn't it? Denser atmosphere, therefore more heat conservation. The greenhouse effect on such worlds depends on carbon dioxide and ammonia vapor. Well, several thousand years ago, t'Kela passed a critical point. Just enough ammonia was lost to reduce the greenhouse effect sharply. As the temperature fell, more and more liquid ammonia turned solid and went to the bottom, where it's also quite well protected against melting. This made the climatic change catastrophically sudden. Temperatures dropped so low that now carbon dioxide also turns liquid, or even solid, through part of the year. There's still some vapor in the atmosphere, in equilibrium, but very little. The greenhouse effect *really* dropped off!

"Plant life was gravely affected, as you can imagine. It can't grow without carbon dioxide and ammonia to build its tissues. Animal life died out with it. Areas the size of a Terrestrial continent became utterly barren, almost overnight. I told you that the native agricultural civilization was wiped out. Worse, though, we've learned from geology that the nitrogen-fixing bacteria were destroyed. Completely. They couldn't survive the winter temperatures. So there's no longer any force to balance the oxidation of ammonia. The deserts encroach everywhere, year by year—and t'Kela's year is only six-tenths Standard. Evolution has worked hard, adapting life to the change, but the pace is now too rapid for it. We estimate that all higher animals, including the natives, will be extinct within another millennium. In ten thousand years there'll be nothing alive here."

Though she had lived with the realization for months, it still shook Joyce to talk about. She clamped fingers around her coffee cup till they hurt, stared out the window at drifting dust, and strove not to cry.

Van Rijn blew foul clouds of smoke a while in silence. Finally he rumbled almost gently, "But you have a cure program worked out, *ja?*"

"Oh . . . oh, yes. We do. The research is completed and we were about ready to summon engineers." She found comfort in proceeding:

"The ultimate solution is to re-introduce nitrogen-fixing bacteria. Our labs have designed an extremely productive strain. It will need a suitable ecology, though, to survive: which means a lot of work with soil chemistry, a microagricultural program. We can hasten everything—begin to show results in a decade—by less subtle methods. In fact, we'll have to do so, or the death process will outrun anything that bacteria can accomplish.

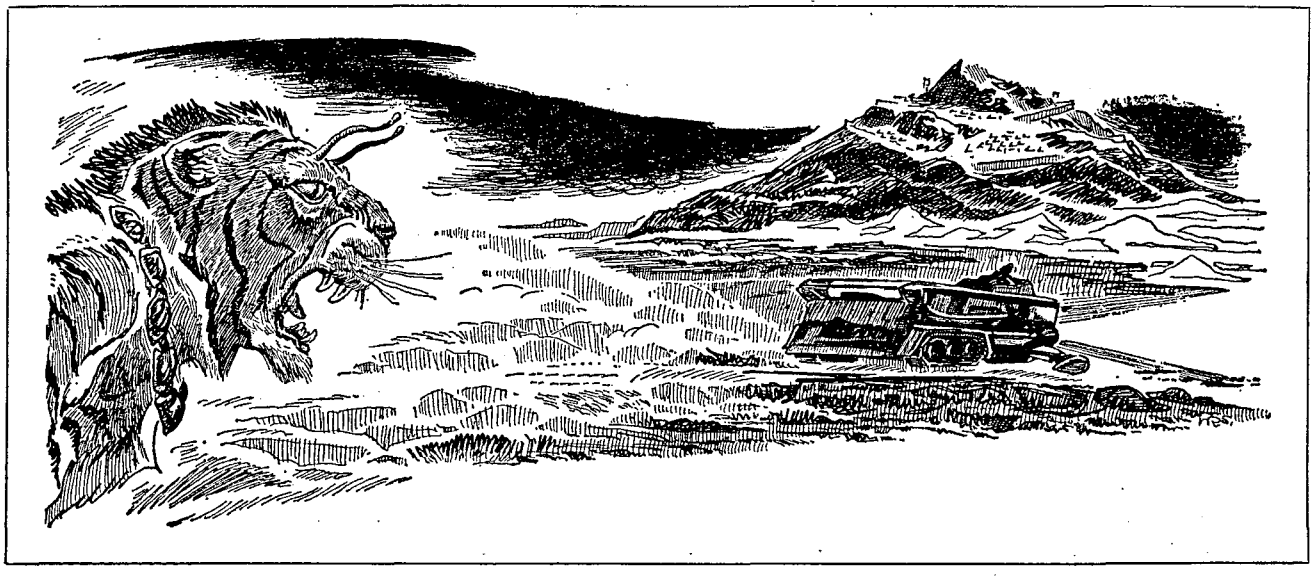
"What we'll do is melt and electrolyze water. The oxygen can be released directly into the air, refreshing it. But some will go to burn local hydrocarbons. T'Kela is rich in petroleum. This burning will generate carbon dioxide, thus strengthening the greenhouse effect. The chemical energy released can also supplement the nuclear power stations we'll install: to do the electrolysis and to energize the combination of hydrogen from water with nitrogen from the atmosphere, recreating ammonia."

"A big expensive job, that," van Rijn said.

"Enormous. The biggest thing Esperance has yet undertaken. But the plans and estimates have been drawn up. We know we can do it."

"If the natives don't go potshotting engineers for exercise after lunch."

"Yes." Joyce's blond head sank low. "That would make it impossible. We have to have the good will of all of them, everywhere. They'll have to co-operate, work with us and each other, in a planet-wide effort.



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And Kusulongo the City influences a quarter of the whole world! What have we done? I thought they were our friends—"

"Maybe we get some warriors and throw sharp things at them till they appreciate us," van Rijn suggested.

The car went swiftly, even over irregular ground. An hour or so after it had started again, Uulobu shouted from his seat on top. Through the overhead window the humans saw him lean across his windshield and point. Looking that way, they saw a dust cloud on the northwestern horizon, wider and lower than the one to the south. "Animals being herded," Uulobu said. "Steer thither, sky-folk."

Joyce translated and van Rijn put the control bar over. "I thought you said they were hunters only," he remarked. "Herds?"

"The Horde people maintain an economy somewhere between that of ancient Mongol cattlekeepers and Amerind bison chasers," she explained. "They don't actually domesticate the *irizu* or the *bambalo*. They did once, before the glacial era, but now the land couldn't support such a concentration of grazers. The Hordes do still exercise some control over the migrations of the herds, though, cull them, and protect them from predators."

"Um-m-m. What are these Hordes, anyhows?"

"That's hard to describe. No human really understands it. Not that t'Kelan psychology is incomprehensible. But it is nonhuman, and our mission has been so busy gathering planetographical data that we never found time to do psychological studies in depth. Words like 'pride,' 'clan,' and 'Horde' are rough translations of native terms—not very accurate. I'm sure—just as 't'Kela' is an arbitrary name of ours for the whole planet. It means 'this earth' in the Kusulongo language."

"Hokay, no need beating me over this poor old eggnoggin with the too obvious. I get the idea. But look you, Freelady Davisson . . . I can call you Joyce?" Van Rijn buttered his tones. "We is in the same boat, sink or swim together, except for having no water to do it in, so let us make friends, ha?" He leaned suggestively against her. "You call me Nicky."

She moved aside. "I cannot prevent your addressing me as you wish, Freeman van Rijn," she said in her frostiest voice.

"Heigh-ho, to be young and not so globulous again! But a lonely old man must swallow his sorrows." Van Rijn sighed like a self-pitying tornado. "Apropos swallowing, *why* is there not so much as one little case beer along? Just one case; one hour or maybe two of sips, to lay the sandstorms in this mummy gullet I got; is that so much to ask, I ask you?"

"Well, there isn't." She pinched her mouth together. They drove on in silence.

Presently they raised the herd: *irizu*, humpbacked and spike-tailed, the size of Terran cattle. Those numbered a few thousand, Joyce estimated from previous experience. With vegetation so sparse, they must needs spread across many kilometers.

A couple of natives had spied the car from a distance and came at a gallop. They rode *basai*, which looked not unlike large stocky antelope with tapir faces and a single long horn. The t'Kelans wore kilts similar to Uulobu's, but leather medallions instead of his shell necklace. Van Rijn stopped the car. The natives reined in. They kept weapons ready, a strung bow and a short throwing-spear.

Uulobo jumped off the top and approached them, hands outspread. "Luck in the kill, strength, health, and offspring!" he wished them in the formal order of importance. "I am Tola's son Uulobu, Avongo, Rokulela, now a follower of the sky-folk."

"So I see," the older, grizzled warrior answered coldly. The young one grinned and put his bow away with an elaborate flourish. Uulobu clapped hand to tomahawk. The older being made a somewhat conciliatory gesture and Uulobu relaxed a trifle.

Van Rijn had been watching intently. "Tell me what they say," he ordered. "Everything. Tell me what this means with their weapon foolishness."

"That was an insult the archer offered Uulobu," Joyce explained unhappily. "Disarming before the ceremonies of peace have been completed. It implies that Uulobu isn't formidable enough to be worth worrying about."

"Ah, so. These is rough peoples, them. Not even inside their own Hordes is peace taken for granted, ha? But why should they make nasty at Uulobu? Has he got no prestige from serving you?"

"I'm afraid not. I asked him about it once. He's the only t'Kelan I could ask about such things."

"*Ja?* How come that?"

"He's the closest to a native intimate that any of us in the mission have had. We saved him from a pretty horrible death, you see. We'd just worked out a cure for a local equivalent of tetanus when he caught the disease. So he feels gratitude toward us, as well as having an economic motive. All our regular assistants are . . . were impoverished, for one reason or another. A drought had killed off too much game in their territory, or they'd been dispossessed, or something like that." Joyce bit her lip. "They . . . they did swear us fealty . . . in the traditional manner . . . and you know how bravely they fought for us. But that was for the sake of their own honor. Uulobu is the only t'Kelan who's shown anything like real affection for humans."

"Odd, when you come here to help them. By damn, but you was a bunch of mackerel heads! You should have begun with depth psychology first of all. That fool planetography could wait . . . Rotten, stinking mackerel, glows blue in the dark . . ." Van Rijn's growl trailed into a mumble. He shook himself and demanded further translation.

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"The old one is called Nyaronga, head of this pride," Joyce related. "The other is one of his sons, of course. They belong to the Gangu clan, in the same Horde as Uulobu's Avongo. The formalities have been concluded and we're invited to share their camp. These people are hospitable enough, in their fashion . . . after bona fides has been established."

The riders dashed off. Uulobu returned. "They must hurry," he reported through the intercom. "The sun will brighten today, and cover is still a goodly ways off. Best we trail well behind so as not to stampede the animals, sky-female." He climbed lithely to the cartop. Joyce passed his words on as van Rijn got the vehicle started.

"One thing at a time, like the fellow said shaking hands with the octopus," the merchant decided. "You must tell me much, but we begin with going back to why the natives are not so polite to anybody who works for your mission."

"Well . . . as nearly as Uulobu could get it across to me, those who came to us were landless. That is, they'd stopped maintaining themselves in their ancestral hunting grounds. This means a tremendous loss of respectability. Then, too, he confessed—very bashfully—that our helpers' prestige suffered because we never involved them in any fights. The imputation grew up that they were cowards."

"A warlike culture, ha?"

"N-no. That's the paradox. They don't have wars, or even vendettas, in our sense. Fights are very small-scale affairs, though they happen constantly. I suppose that arises from the political organization. Or does it? We've noticed the same thing in remote parts of t'Kela, among altogether different societies from the Horde culture."

"Explain that, if you will be so kind as to make me a little four-decker sandwich while you talk."

Joyce bit back her annoyance and went to the cooker table. "As I said, we never did carry out intensive xenological research, even locally," she told him. "But we do know that the basic social unit is the same everywhere on this world, what we call the pride. It springs from the fact that the sex ratio is about three females to one male. Living together you have the oldest male, his wives, their offspring of sub-adult age. All males, and females unencumbered with infants, share in hunting, though only males fight over t'Kelans. The small, um, children help out in the work around camp. So do any widows of the leader's father that he's taken in. The size of such a pride ranges up to twenty or so. That's as many as can make a living in an area small enough to cover afoot, on this desert planet."

"I see. The t'Kelan pride answers to the human family. It is just as universal, too, right? I suppose larger units get organized in different ways, depending on the culture."

"Yes. The most backward savages have no organization larger than the pride. But the Kusulongo society, as we call it—the Horde people—the biggest and most advanced culture, spread over half the northern hemisphere—it has a more elaborate superstructure. Ten or twenty prides form what we call a clan, a co-operative group claiming descent from a common male ancestor, controlling a large territory through which they follow the wild herds. The clans in turn are loosely federated into Hordes, each of which holds an annual get-together in some traditional oasis. That's when they trade, socialize, arrange marriages—newly adult males get wives and start new prides—yes, and they adjudicate quarrels, by arbitration or combat, at such times. There's a lot of squabbling among clans, you see, over points of honor or practical matters like ammonia wells. One nearly always marries within one's own Horde; it has its own dress, customs, gods, and so forth."

"No wars between Hordes?" van Rijn asked.

"No, unless you want to call the terrible things that happen during a *Völkerwanderung* a war. Normally, although individual units from different Hordes may clash, there isn't any organized campaigning. I suppose they simply haven't the economic surplus to maintain armies in the field."

"Um-m-m. I suspect, me, the reason goes deeper than that. When humans want to have wars, by damn, they don't let any little questions of if they can afford it stop them. I doubt t'Kelans would be any different. Um-m-m." Van Rijn's free hand tugged his goatee. "Maybe here is a key that goes tick-a-tock and solves our problem, if we know how to stick it in."

"Well," Joyce said, "the Ancients are also a war preventive. They settle most inter-Horde disputes, among other things."

"Ah, yes, those fellows on the mountain. Tell me about them."

Joyce finished the sandwich and gave it to van Rijn. He wolfed it noisily. She sat down and stared out at the scene: brush and boulders and swirling dust under the surely red light, the dark mass of the herd drifting along, a rider who galloped back to head off some stragglers. Far ahead now could be seen the Lumbambaru, a range of ice, sharp peaks that shimmered against the crepuscular sky. Faintly to her, above the murmur of the engine, came yelps and the lowing of the animals. The car rocked and bumped; she felt the terrain in her bones.

"The Ancients are survivors of the lost civilization," she said. "They hung on in their city, and kept the arts that were otherwise forgotten. That kind of life doesn't come natural to most t'Kelans. I gather that in the course of thousands of years, those who didn't like it there wandered down to join the nomads, while occasional nomads who thought the city would be congenial went up and were adopted into the group. That would make for some genetic selection. The Ancients are a distinct psychological type. Much more reserved and . . . intellectual, I guess you'd call it . . . than anyone else."

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"How they make their living?" van Rijn asked around a mouthful.

"They provide services and goods for which they are paid in kind. They are scribes, who keep records; physicians; skilled metallurgists; weavers of fine textiles; makers of gunpowder, though they only sell fireworks and keep a few cannon for themselves. They're credited with magical powers, of course, especially because they can predict solar flares."

"And they was friendly until yesterday?"

"In their own aloof, secretive fashion. They must have been plotting the attack on us for some time, though, egging on the Shanga and furnishing the power to blow open our dome. I still can't imagine why. I'm certain they believed us when we explained how we'd come to save their race from extinction."

"*Ja,* no doubt. Only maybe at first they did not see all the implications." Van Rijn finished eating, belched, picked his teeth with a fingernail, and relapsed into brooding silence. Joyce tried not to be too desperately homesick.

After a long time, van Rijn smote the control board so that it rang. "It fits together!" he bellowed.

"What?" Joyce sat straight.

"But I still can't see how to use it," he said.

"What do you mean?"

"Shut up, Freelady." He returned to his thoughts. The slow hours passed.

Late in the afternoon, a forest hove into sight. It covered the foothills of the Lubambaru, where an ammonia river coursed thinly and seepage moistened the soil a little. The trees were low and gnarled, with thorny blue trunks and a dense foliage of small greenish-gray leaves. Tall shrubs sprouted in thickets between them. The riders urged their *iziru* into the wood, posted a few pickets to keep watch, and started northward in a compact group, fifteen altogether, plus pack animals and a couple of fuzzy infants in arms. The females were stockier than the males and had snouted faces. Though hairy and homeothermic, the t'Kelans were not mammals; mothers regurgitated food for children who had not yet cut their fangs.

Old Nyaronga led the band, sword rattling at his side, spear in hand and shield on arm, great yellow eyes flickering about the landscape. His half-grown sons flanked the party, arrows nocked to bows. Van Rijn trundled the car in their wake. "They expect trouble?" he asked.

Joyce started from her glum thoughts. "They always expect trouble," she said. "I told you, didn't I, what a quarrelsome race this is—no wars, but so many bloody set-tos. However, their caution is just routine today. Obviously they're going to pitch camp with the other prides of their clan. A herd this size would require all the Gangu to control it."

"You said they was hunters, not herders."

"They are, most of the time. But you see, *iziru* and *bambalo* stampede when the sun flares, and many are so badly sunburned that they die. That must be because they haven't developed protection against ultraviolet since the atmosphere began to change. Big animals with long generations evolve more slowly than small ones, as a rule. The clans can't afford such losses. In a flare season like this, they keep close watch on the herds and force them into areas where there is some shade and where the undergrowth hinders panicky running."

Van Rijn's thumb jerked a scornful gesture at the lowering red disk. "You mean that ember ever puts out enough radiation to hurt a sick butterfly?"

"Not if the butterfly came from Earth. But you know what type M dwarfs are like. They flare, and when they do, it can increase their luminosity several hundred per cent. These days on t'Kela, the oxygen content of the air has been lowered to a point where the ozone layer doesn't block out as much ultraviolet as it should. Then, too, a planet like this, with a metal-poor core, has a weak magnetic field. Some of the charged particles from the sun get through also—adding to an already high cosmic ray background. It wouldn't bother you or me, but mankind evolved to withstand considerably more radiation than is the norm here."

"*Ja,* I see. Maybe also there not being much radioactive minerals locally has been a factor. On Throra, the flares don't bother them. They make festival then. But like you say, t'Kela is a harder luck world than Throra."

Joyce shivered. "This is a cruel cosmos. That's what we believe in on Esperance—fighting back against the universe, all beings together."

"Is a very nice philosophy, except that all beings is not built for it. You is a very sweet child, anyone ever tell you that?" Van Rijn laid an arm lightly across her shoulder. She found that she didn't mind greatly, with the gloom and the brewing star-storm outside.

In another hour they reached the campsite. Humpbacked leather tents had been erected around a flat field where there was an ammonia spring. Fires burned before the entrances, tended by the young. Females crouched over cooking pots, males swaggered about with hands on weapon hilts. The arrival of the car brought everyone to watch, not running, but strolling up with an elaborate pretense of indifference.

Or is it a pretense? Joyce wondered. She looked out at the crowd, a couple of hundred unhuman faces, eyes aglow, spearheads agleam, ruddy crests tossed by the whimpering wind, but scarcely a sound from anyone. *They've acted the same way, every clan and Horde, everywhere we encountered them: wild fascination at first, with our looks and our machines; then a lapse into this cool formal courtesy, as if we didn't make any real difference for good or ill. They've thanked us, not very warmly, for what favors we could do, and often insisted*

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on making payment, but they've never invited us to their merrymaking or their rites, and sometimes the children throw rocks at us.

Nyaronga barked a command. His pride began pitching their own camp. Gradually the others drifted away.

Van Rijn glanced at the sun. "They sure it flares today?" he asked.

"Oh, yes. If the Ancients have said so, then it will," Joyce assured him. "It isn't hard to predict, if you have smoked glass and a primitive telescope to watch the star surface. The light is so dim that the spots and flare phenomena can easily be observed—unlike a G-type star—and the patterns are very characteristic. Any jackleg astronomer can predict a flare on an M class dwarf, days in advance. Heliograph signals carry the word from Kusulongo to the Hordes."

"I suppose the Old Fogies got inherited empirical knowledge from early times, like the Babylonians knew about planetary movements, *ja* . . . Whoops, speak of the devil, here we go!"

The sun was now not far above the western ridges, which stood black under its swollen disk. A thin curl of clearer red puffed slowly out of it on one side. The *basai* reared and screamed. A roar went through the clansfolk. Males grabbed the animals' bridles and dragged them to a standstill. Females snatched their pots and their young into the tents.

The flame expanded and brightened. Light crept along the shadowy hills and the plains beyond. The sky began to pale. The wind strengthened and threshed in the woods on the edge of camp.

The t'Kelans manhandled their terrified beasts into a long shelter of hides stretched over poles. One bolted. A warrior twirled his lariat, tossed, and brought the creature crashing to earth. Two others helped drag it under cover. Still the flame from the solar disk waxed and gathered luminosity, minute by minute. It was not yet too brilliant for human eyes to watch unprotected. Joyce saw how a spiderweb of forces formed and crawled there, drawn in fiery loops. A gout of radiance spurted, died, and was reborn. Though she had seen the spectacle before, she found herself clutching van Rijn's arm. The merchant stuffed his pipe and blew stolid fumes.

Uulobu got down off the car. Joyce heard him ask Nyaronga, "May I help you face the angry Real One?"

"No," said the patriarch. "Get in a tent with the females."

Uulobu's teeth gleamed. The fur rose along his back. He unhooked the tomahawk at his waist.

"Don't!" Joyce cried through the intercom. "We are guests!"

For an instant the two t'Kelans glared at each other. Nyaronga's spear was aimed at Uulobu's throat. Then the Avongo sagged a little. "We are guests," he said in a choked voice. "Another time, Nyaronga, I shall talk about this with you."

"You—landless?" The leader checked himself. "Well, peace has been said between us, and there is no time now to unsay it. But we Gangu will defend our own herds and pastures. No help is needed."

Stiff-legged, Uulobu went into the nearest tent. Presently the last *basai* were gotten inside the shelter. Its flap was laced shut, to leave them in soothing darkness.

The flare swelled. It became a ragged sheet of fire next the sun disk, almost as big, pouring out as much light, but of an orange hue. Still it continued to grow, to brighten and yellow. The wind increased.

The heads of prides walked slowly to the center of camp. They formed a ring; the unwed youths made a larger circle around them. Nyaronga himself took forth a brass horn and winded it. Spears were raised aloft, swords and tomahawks shaken. The t'Kelans began to dance, faster and faster as the radiance heightened. Suddenly Nyaronga blew his horn again. A cloud of arrows whistled toward the sun.

"What they doing?" van Rijn asked. "Exorcising the demon?"

"No," said Joyce. "They don't believe that's possible. They're defying him. They always challenge him to come down and fight. And he's not a devil, by the way, but a god."

Van Rijn nodded. "It fits the pattern," he said, half to himself. "When a god steps out of his rightful job, you don't try to bribe him back, you threaten him. *Ja*, it fits."

The males ended their dance and walked with haughty slowness to their tents. The doorflaps were drawn. The camp lay deserted under the sun.

"Ha!" Van Rijn surged to his feet. "My gear!"

"What?" Joyce stared at him. She had grown so used to wan red light on this day's travel that the hue now pouring in the windows seemed ghastly on his cheeks.

"I want to go outside," van Rijn told her. "Don't just stand there with tongue unreeled. Get me my suit!"

Joyce found herself obeying him. By the time his gross form was bedecked, the sun was atop the hills and had tripled its radiance. The flare was like a second star, not round but flameshaped, and nearly white. Long shadows wavered across the world, which had taken on an unnatural brass tinge. The wind blew dust and dead leaves over the ground, flattened the fires and shivered the tents till they thundered.

"Now," van Rijn said, "when I wave, you fix your intercom to full power so they can hear you. Then tell those so-called males to peek out at me if they have the guts." He glared at her. "And be unpolite about it, you understand me?"

Before she could reply he was in the air lock. A minute afterward he had cycled through and was stumping over the field until he stood in the middle of the encampment. Curtly, he signaled.

Joyce wet her lips. What did that idiot think he was

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doing? He'd never heard of this planet a month ago. He hadn't been on it a week. Practically all his information about it he had from her, during the past ten or fifteen hours. And he thought he knew how to conduct himself? Why, if he didn't get his fat belly full of whetted iron, it would only be because there was no justice in the universe. *Does he think I'll let myself be dragged down with him?*

Etched huge and black against the burning sky, van Rijn jerked his arm again.

Joyce turned the intercom high and said in the vernacular: "Watch, all Gangu who are brave enough! Look upon the male from far places, who stands alone beneath the angered sun!"

Her tones boomed hollowly across the wind. Van Rijn might have nodded. She must squint now to see what he did. That was due to the contrast, not the illumination per se. It was still only a few per cent of what Earth gets. But the flare, with an effective temperature of a million degrees or better, was emitting in frequencies to which her eyes were sensitive. Ultraviolet also, she thought in a corner of her mind: too little to turn a human baby pink, but enough to bring pain or death to these poor dwellers in Hades.

Van Rijn drew his blaster. With great deliberation, he fired several bolts at the star. Their flash and noise seemed puny against the rage up there. Now what—?

"No!" Joyce screamed.

Van Rijn opened his face plate. He made a show of it, sticking his countenance out of the helmet, into the full light. He danced grotesquely about and thumbed his craggy nose at heaven.

But. . .

The merchant finished with an unrepeatable gesture, closed his helmet again, fired off two more bolts, and stood with folded arms as the sun went under the horizon.

The flame lingered in view for a while, a sheet of ghostly radiance above the trees. Van Rijn walked back to the car through twilight. Joyce let him in. He opened his helmet, wheezing, weeping, and blaspheming in a dozen languages. Frost began to form on his suit.

"Hoo-ee!" he moaned. "And not even a little hundred cc. of whisky to console my poor old mucky membranes!"

"You could have died," Joyce whispered.

"Oh, no. No. Not that way does Nicholas van Rijn die. At the age of a hundred and fifty, I plan to be shot by an outraged husband. The cold was not too bad, for the short few minutes I could hold my breath. But letting in that ammonia— Terror and taxes!" He waddled to the bath cubicle and splashed his face with loud snortings.

The last flare-light sank. The sky remained hazy with aurora, so that only the brightest stars showed. The most penetrating charged particles from the flare would not arrive for hours; it was safe outside. One by one, the t'Kelans emerged. Fires were poked up, sputtering and glaring in the dark.

Van Rijn came back. "Hokay, I'm set," he said. "Now put on your own suit and come out with me. We got to talk at them."

As she walked into the circle around which stood the swart outlines of the tents, Joyce must push her way through females and young. Their ring closed behind her, and she saw fireglow reflected from their eyes and knew she was hemmed in. It was comforting to have van Rijn's bulk so near and Uulobu's *pad-pad* at her back.

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Thin comfort, though, when she looked at the males who waited by the ammonia spring. They had gathered as soon as they saw the humans coming. To her vision they were one shadow, like the night behind them. The fires on either side, that made it almost like day for a t'Kelan, hardly lit the front rank for her. Now and then a flame jumped high in the wind, or sparks went showering, or the dull glow on the smoke was thrown toward the group. Then she saw a barbed obsidian spearhead, a horn sword, an ax or an iron dagger, drawn. The forest soughed beyond the camp and she heard the frightened bawling of *iziru* as they blundered around in the dark. Her mouth went dry.

The fathers of the prides stood in the forefront. Most were fairly young; old age was not common in the desert. Nyaronga seemed to have primacy on that account. He stood spear in hand, fangs showing in the half-open jaws, tendrils astir. His crest and kilt fluttered in the unrestful air.

Van Rijn came to a halt before him. Joyce made herself stand close and meet Nyaronga's gaze. Uulobu crouched at her feet. A murmur like the sigh before a storm went through the warriors.

But the Earthman waited imperturbable, until at last Nyaronga must break the silence. "Why did you challenge the sun? No sky-one has ever done so before."

Joyce translated, a hurried mumble. Van Rijn puffed himself up, visibly even in his suit. "Tell him," he said, "I came just a short time ago. Tell him the rest of you did not think it was worth your whiles to make defiance, but I did."

"What do you intend to do?" she begged. "A misstep could get us killed."

"True. But if we don't make any steps, we get killed for sure, or starve to death because we don't dare come in radio range of where the rescue ship will be. Not so?" He patted her hand. "Damn these gloves! This would be more fun without. But in all kinds of cases, you trust me, Joyce. Nicholas van Rijn has not got old and fat on a hundred rough planets, if he was not smart enough to outlive everybody else. Right? Exact. So tell whatever I say to them, and use a sharp tone. Not unforgivable insults, but be snotty, hokay?"

She gulped. "Yes. I don't know why, b-but I will let you take the lead. If—" She suppressed fear and turned to the waiting t'Kelans. "This sky-male with me is not one of my own party," she told them. "He is of my race, but from a more powerful people among them than my people. He wishes me to tell you that though we sky-folk have hitherto not deigned to challenge the sun, he has not thought it was beneath him to do so."

"You never deigned?" rapped someone. "What do you mean by that?"

Joyce improvised: "The brightening of the sun is no menace to our people. We have often said as much. Were none of you here ever among those who asked us?"

Stillness fell again for a moment, until a scarred one-eyed patriarch said grudgingly: "Thus I heard last year, when you or one like you were in my pride's country healing sick cubs."

"Well, now you have seen it is true," Joyce replied.

Van Rijn tugged her sleeve. "Hoy, what goes on? Let me talk or else our last chance gets stupided away."

She dared not let herself be angered, but recounted the exchange. He astonished her by answering, "I am sorry, little girl. You was doing just wonderful. Now, though, I have a speech to make. You translate as I finish every sentence, ha?"

He leaned forward and stabbed his index finger just beneath Nyaronga's nose, again and again, as he harshed: "You ask why I went out under the brightening sun? It was to show you I am not afraid of the fire it makes. I spit on your sun and it sizzles. Maybe it goes out. My sun could eat yours for breakfast and want an encore, by damn! Your little clot hardly gives enough light to see by, not enough to make bogeyman for a baby in my people."

The t'Kelans snarled and edged closer, hefting their weapons. Nyaronga retorted indignantly, "Yes, we have often observed that you sky-folk are nearly blind."

"You ever stood in the light from our cars? You go blind then, *nie?* You could not stand Earth, you. Pop and sputter you'd go, up in a little greasy cloud of smoke."

They were taken aback at that. Nyaronga spat and said, "You must even bundle yourselves against the air."

"You saw me stick my head out in the open. You care to try a whiff of my air for a change? I dare you."

A rumble went through the warriors, half wrath and half unease. Van Rijn chopped contemptuously with one hand. "See? You is more weakling than us."

A big young chieftain stepped forward. His whiskers bristled. "I dare."

"Hokay, I give you a smell." Van Rijn turned to Joyce. "Help me with this bebloodied air unit. I don't want no more of that beetle venom they call air in my helmet."

"But . . . but—" Helplessly, she obeyed, unscrewing the flush valve on the recycler unit between his shoulders.

"Blow it in his face," van Rijn commanded.

The warrior stood bowstring taut. Joyce thought of the pain he must endure. She couldn't aim the hose at him. "Move!" van Rijn barked. She did. Terrestrial atmosphere gushed forth.

The warrior yowled and stumbled back. He rubbed his nose and streaming eyes. For a minute he wobbled around, before he collapsed into the arms of a follower. Joyce refitted the valve as van Rijn chortled, "I knew it. Too hot, too much oxygen, and especial the water vapor. It makes Throrans sick, so I thought sure it would do the same for these chaps. Tell them he will get well in a little while."

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Joyce gave the reassurance. Nyaronga shook himself and said, "I have heard tales about this. Why must you show that poor fool what was known, that you breathe poison?"

"To prove we is just as tough as you, only more so, in a different way," van Rijn answered through Joyce. "We can whip you to your kennels like small dogs if we choose."

That remark brought a yell. Sharpened stone flashed aloft. Nyaronga raised his arms for silence. It came, in a mutter and grumble and a deep sigh out of the females watching from darkness. The old chief said with bleak pride, "We know you command weapons we do not. This means you have arts we lack, which has never been denied. It does not mean you are stronger. A t'Kelan is not stronger than a *bambalo* simply because he has a bow to kill it from afar. We are a hunter folk and you are not, whatever your weapons."

"Tell him," van Rijn said, "that I will fight their most powerful man barehanded. Since I must wear this suit that protects from his bite, he can use armaments. They will go through fabricord, so it is fair, *nie?*"

"He'll kill you," Joyce protested.

"If so," van Rijn leered, "I die for the most beautifullest lady on this planet." His voice dropped. "Maybe then you is sorry you was not more kind to a nice old man when you could be."

"I won't!"

"You will, by damn!" He seized her wrist so strongly that she winced. "I know what I am making."

Numbly, she conveyed the challenge. Van Rijn drew his blaster and threw it at Nyaronga's feet. "If I lose, the winner can keep this," he said.

That fetched them. A dozen wild young males leaped forth, shouting, into the firelight. Nyaronga roared and cuffed them into order. He glared from one to another and jerked his spear at an individual. "This is my own son Kusalu. Let him defend the honor of pride and clan."

The t'Kelan was overtopped by van Rijn, but was almost as broad. Muscles moved snakish under his fur. His fangs glistened as he slid forward, tomahawk in his right hand, iron dagger in left. The other males fanned out, making a wide circle of eyes and poised weapons. Uulobu drew Joyce aside. His grasp trembled on her arm. "Could I but fight him myself," he whispered.

Van Rijn turned, ponderous as a planet, while Kusalu glided about. His arms hung apelike from hunched shoulders. The fires tinged his crude features where they jutted within the helmet. "Nyaaah," he said.

Kusalu cursed and threw the tomahwak with splintering force. Van Rijn's left hand moved at an impossible speed. He caught the weapon in midair and threw himself backward. The thong tautened. Kusalu went forward on his face. Van Rijn plunged to the attack.

Kusalu rolled over and bounced to his feet in time. His blade flashed. Van Rijn blocked it with his right wrist. The Earthman's left hand took a hitch in the thong and yanked again. Kusalu went to one knee. Van Rijn twisted that arm around behind his back. Every t'Kelan screamed.

Kusalu slashed the thong across. Spitting, he leaped erect again and pounced. Van Rijn gave him an expert kick in the belly, withdrawing the foot before it could be seized. Kusalu lurched. Van Rijn closed in with a karate chop to the side of the neck.

Kusalu staggered but remained up. Van Rijn barely ducked the rip of the knife. He retreated. Kusalu stood a moment regaining his wind. Then he moved in one blur.

Things happened. Kusalu was grabbed as he charged and sent flailing over van Rijn's shoulder. He hit ground with a thump. Van Rijn waited. Kusalu still had the dagger. He rose and stalked near. Blood ran from his nostril.

"*Là ci darem la mano,*" sang van Rijn. As Kusalu prepared to smite, the Earthman got a grip on his right arm, whirled him around, and pinned him.

Kusalu squalled. Van Rijn ground a knee in his back. "You say uncle?" he panted.

"He'll die first," Joyce wailed.

"Hokay, we do it hard fashion." Van Rijn forced the knife loose and kicked it aside. He let Kusalu go. But the t'Kelan had scarcely raised himself when a gauntleted fist smashed into his stomach. He reeled. Van Rijn pushed in relentlessly, blow after blow, until the warrior sank.

The merchant stood aside. Joyce stared at him with horror. "Is all in order," he calmed her. "I did not damage him permanent."

Nyaronga helped his son climb back up. Two others led Kusalu away. A low keening went among the massed t'Kelans. It was like nothing Joyce had ever heard before.

Van Rijn and Nyaronga confronted each other. The native said very slowly, "You have proven yourself, skymale. For a landless one, you fight well, and it was good of you not to slay him."

Joyce translated between sobs. Van Rijn answered, "Say I did not kill that young buck because there is no need. Then say I have plenty territory of my own." He pointed upward, where stars glistened in the windy, hazy sky. "Tell him there is my hunting grounds, by damn."

When he had digested this, Nyaronga asked almost plaintively, "But what does he wish in our land? What is his gain?"

"We came to help—" Joyce stopped herself and put the question to van Rijn.

"Ha!" the Earthman gloated. "Now we talk about turkeys." He squatted near a fire. The pride fathers joined him; their sons pressed close to listen. Uulobu breathed happily, "We are taken as friends."

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"I do not come to rob your land or game," van Rijn said in an oleaginous tone. "No, only to make deals, with good profit on both sides. Surely these folks trade with each other. They could not have so much stuffs as they do otherwise."

"Oh, yes, of course." Joyce settled weakly beside him. "And their relationship to the city is essentially quid pro quo, as I told you before."

"Then they will understand bargains being struck. So tell them those Gaffers on the mountain has got jealous of us. Tell them they sicked the Shanga onto our camp. The whole truths, not varnished more than needful."

"What? But I thought . . . I mean, didn't you want to give them the impression that we're actually powerful? Should we admit we're refugees?"

"Well, say we has had to make a . . . what do the military communiques say when you has got your pants beaten off? . . . an orderly rearward advance for strategic reasons, to previously prepared positions."

Joyce did. Crests rose on the native heads, pupils narrowed and hands raised weapons anew. Nyaronga asked dubiously, "Do you wish shelter among us?"

"No," said van Rijn. "Tell him we is come to warn them, because if they get wiped out we can make no nice deals with profit. Tell them the Shanga now has your guns from the dome, and will move with their fellow clans into Rokulela territory."

Joyce wondered if she had heard aright. "But we don't . . . we didn't . . . we brought no weapons except a few personal sidearms. And everybody must have taken his own away with him in the retreat."

"Do they know that, these peoples?"

"Why . . . well . . . would they believe you?"

"My good pretty blonde with curves in all the right places, I give you Nicholas van Rijn's promise they would not believe anythings else."

Haltingly, she spoke the lie. The reaction was horrible. They boiled throughout the camp, leaped about, brandished their spears and ululated like wolves. Nyaronga alone sat still, but his fur stood on end.

"Is this indeed so?" he demanded. It came as a whisper through the noise.

"Why else would the Shanga attack us, with help from the Ancients?" van Rijn countered.

"You know very well why," Joyce said. "The Ancients bribed them, played on their superstitions, and probably offered them our metal to make knives from."

"*Ja*, no doubt, but you give this old devil here my rhetorical just the way I said it. Ask him does it not make sense, that the Shanga would act for the sake of blasters and slugthrowers, once the Geezers put them up to it and supplied gunpowder? Then tell him this means the Graybeards must be on the side of the Shanga's own Horde—what's they called, now?"

"The Yagola."

"So. Tell him that things you overheard give you good reason to believe the Shanga clan will put themselves at the head of the Yagola to move west and push the Rokulela out of this fine country."

Nyaronga and the others, who fell into an ominous quiet as Joyce spoke, had no trouble grasping the concept. As she had told van Rijn, war was not a t'Kelan institution. But she was not conveying the idea of a full-dress war—rather, a *Völkerwanderung* into new hunting grounds. And such things were frequent enough on this dying planet. When a region turned utterly barren, its inhabitants must displace someone else, or die in the attempt.

The difference now was that the Yagola were not starved out of their homes. They were alleged to be anticipating that eventuality, plotting to grab off more land with their stolen firearms to give them absolute superiority.

"I had not thought them such monsters," Nyaronga said.

"They aren't," Joyce protested in Anglic to van Rijn. "You're maligning them so horribly that . . . that—"

"Well, well, all's fair in love and propaganda," he said. "Propose to Nyaronga that we all return to Kusulongo, collecting reinforcements as we go, to see for ourselves if this business really is true and use numerical advantage while we have still got it."

"You *are* going to set them at each other's throats! I won't be party to any such thing. I'll die first."

"Look, sweet potato, nobody has got killed yet. Maybe nobody has to be. I can explain later. But for now, we have got to strike while the fat is in the fire. They is wonderful excited. Don't give them a chance to cool off till they has positive decided to march." The man laid a hand on his heart. "You think old, short of breath, comfort-loving, cowardly Nicholas van Rijn wants to fight a war? You think again. A form-fitting chair, a tall cool drink, a Venusian cigar, *Eine Kleine Nachtmusik* on the taper, aboard his ketch while he sails with a bunch of dancing girls down Sunda Straits, that is only which he wants. Is that much to ask? Be like your own kind, gentle selfs and help me stir them up to fight."

Trapped in her own bewilderment, she followed his lead. That same night riders went out, bearing messages to such other Rokulela clans as were known to be within reach.

The first progress eastward was in darkness, to avoid the still flaring sun. Almost every male, grown or half grown, rode along, leaving females and young behind in camp. They wore flowing robes and burnooses, their *basai* were blanketed, against the fierce itch that attacked exposed t'Kelan skin during such periods. Most of the charged particles from the star struck the planet's dayside, but there was enough magnetic field to bring some around to the opposite hemisphere. Even so, the party made surprisingly good speed. Peering from the car windows, Joyce glimpsed them under the two

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moons, shadowy shapeless forms that slipped over the harsh terrain, an occasional flash of spearheads. Through the engine's low voice she heard them calling to each other, and the deep earth-mutter of unshod hoofs.

"You see," van Rijn lectured, "I am not on this world long, but I been on a lot of others, and read reports about many more. In my line of business this is needful. They always make parallels. I got enough clues about these t'Kelans to guess the basic pattern of their minds, from analogizings. You Esperancers, on this other hand, has not had so much experience. Like most colonies, you is too isolated from the galactic mainstream to keep *au courant* with things, like for instance the modern explorer techniques. That was obvious from the fact you did not make depth psychology studies the very first thing, but instead took what you found at face valuation. Never do that, Joyce. Always bite the coin that feeds you, for this is a hard and wicked universe."

"You seem to know what you're about, Nick," she admitted. He beamed and raised her hand to his lips. She made some confused noise about heating coffee and retreated. She didn't want to hurt his feelings; he really was an old dear, under that crust of his.

When she came back to the front seat, placing herself out of his reach, she said, "Well, tell me, what pattern did you deduce? How do their minds work?"

"You assumed they was like warlike human primitives, in early days on Earth," he said. "On the topside, that worked hokay. They is intelligent, with language; they can reason and talk with you; this made them seem easy understood. What you forgot, I think, me, was conscious intelligence is only a small part of the whole selfness. All it does is help us get what we want. But the wanting itself—food, shelter, sex, everything—our motives—they come from deeper down. There is no logical reason even to stay alive. But instinct says to, so we want to. And instinct comes from very old evolution. We was animals long before we became thinkers and, uh"—van Rijn's beady eyes rolled piously ceilingward— "and was given souls. You got to think how a race evolved before you can take them . . . I mean understand them.

"Now humans, the experts tell me, got started way back when, as ground apes that turned carnivore when the forests shrank up in Africa for lots of megayears. This is when they started to walking erect the whole time, and grew hands fully developed to make weapons because they had not claws and teeth like lions. Hokay, so we is a mean lot, we Homo Sapienses, with killer instincts. But not exclusive. We is still omnivores who can even survive on Brussels sprouts if we got to. *Pfui!* But we can. Our ancestors been peaceful nutpluckers and living off each other's fleas a long, longer time than they was hunters. It shows.

"The t'Kelans, on the other side, has been carnivores since they was still four-footers. Not very good carni-

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vores. Unspecialized, with no claws and pretty weak biting apparatus even if it is stronger than humans'. That is why they also developed hands and made tools, which led to them getting big brains. Nevertheleast, they have no vegetarian whatsolutely in their ancestors, as we do. And they have much powerfuller killing instincts than us. And is not so gregarious. Carnivores can't be. You get a big concentration of hunters in one spot, and by damn, the game goes away. Is that coffee ready?"

"I think so." Joyce fetched it. Van Rijn slurped it down, disregarding a temperature that would have taken the skin off her palate, steering with one bare splay foot as he drank.

"I begin to see," she said with growing excitement. "That's why they never developed true nations or fought real wars. Big organizations are completely artificial things to them, commanding no loyalty. You don't fight or die for a Horde, any more than a human would fight for . . . for his bridge club."

"Um-m-m, I have known some mighty bloodshot looks across bridge tabls. But *ja,* you get the idea. The pride is a natural thing here, like the human family. The clan, with blood ties, is only one step removed. It can excite t'Kelans as much, maybe, as his country can excite a man. But Hordes? *Nie.* An arrangement of convenience only.

"Not that pride and clan is loving kindness and sugar candy. Humans make family squabbles and civil wars. T'Kelans have still stronger fighting instincts than us. Lots of arguments and bloodshed. But only on a small scale, and not taken too serious. You said to me, is no vendettas here. That means somebody killing somebody else is not thought to have done anything bad. In fact, whoever does not fight—male, anyhow—strikes them as unnatural, like less than normal."

"Is . . . that why they never warmed up to us? To the Esperancian mission, I mean?"

"Partly. Not that you was expected to fight at any specifical time. Nobody went out to pick a quarrel when you gave no offense and was even useful. But your behavior taken in one lump added up to a thing they couldn't understand. They figured there was something wrong with you, and felt a goodly natured contempt. I had to prove I was tough as they or tougher. That satisfied their instincts, which then went to sleep and let them listen to me with respects."

Van Rijn put down his empty cup and took out his pipe. "Another thing you lacked was territory," he said. "Animals on Earth, too, has an instinct to stake out and defend a piece of ground for themselves. Humans do. But for carnivores this instinct has got to be very, very, very powerful, because if they get driven away from where the game is, they can't survive on roots and berries. They die.

"You saw yourselfs how those natives what could not maintain a place in their ancestral hunting grounds, but went to you instead, was looked downwards on. You Esperancers only had a dome on some worthless nibble of land. Then you went around preaching how you had no designs on anybody's country. Ha! They had to believe you was either lying—maybe that is one reason the Shanga attacked you—or else was abnormal weaklings."

"But couldn't they understand?" Joyce asked. "Did they expect us, who didn't even look like them, to think the same way as they do?"

"Sophisticated, civilized t'Kelans could have caught the idea," van Rijn said. "However, you was dealing with naïve barbarians."

"Except the Ancients. I'm sure they realize—"

"Maybe so. Quite possible. But you made a deadly threat to them. Could you not see? They has been the scribes, doctors, high-grade artisans, sun experts, for ages and ages. You come in and start doing the same as them, only much better. What you expect them to do? Kiss your foots? Kiss any part of your anatomy? Not them! They is carnivores, too. They fight back."

"But we never meant to displace them!"

"Remember," van Rijn said, wagging his pipestem at her, "reason is just the lackey for instinct. The Gaffers is more subtle than anybody elses. They can sit still in one place, between walls. They do not hunt. They do not claim thousands of square kilometers for themselves. But does this mean they have no instinct of territoriality? Ha! Not bloody likely! They has only sublimed it. Their work, *that* is their territory—and you moved in on it!"

Joyce sat numbly, staring out into night. Time passed before she could protest: "But we explained to them—I'm sure they understood . . . We explained this planet will die without our help."

"*Ja, ja.* But a naturally born fighter has less fear of death than other kinds animals. Besides, the death was scheduled for a thousand years from now, did you not say? That is too long a time to feel with emotions. Your own threat to them was real, here and now."

Van Rijn lit his pipe. "Also," he continued around the mouthpiece, "your gabbing about planetwide cooperation did not sit so well. I doubt they could really comprehend it. Carnivores don't make co-operations except on the most teensy scale. It isn't practical for them. They haven't got such instincts. The Hordes—which, remember, is not nations in any sense—they could never get what you was talking about, I bet. Altruism is outside their mental horizontals. It only made them suspicious of you. The Ancients maybe had some vague notion of your motives, but didn't share them in the littlest. You can't organize these peoples. Sooner will you build a carousel on Saturn's rings. It does not let itself be done."

"You've organized them to fight!" she exclaimed in her anguish.

"No. Only given them a common purpose for this time being. They believed what I said about weapons

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left in the dome. With minds like that, they find it much the easiest thing to believe. Of course you had an arsenal —everybody does. Of course you would have used it if you got the chance—anybody would. Ergo, you never got the chance; the Shanga captured it too fast. The rest of the story, the Yagola plot against the Rokulela, is at least logical enough to their minds that they had better investigate it good."

"But what are you going to make them do?" She couldn't hold back the tears any longer. "Storm the mountain? They can't get along without the Ancients."

"Sure, they can, if humans substitute."

"B-b-but . . . but . . . no, we can't, we mustn't—"

"Maybe we don't have to," van Rijn said. "I got to play by my ear of tinned cauliflower when we arrive. We will see." He laid his pipe aside. "There, there, now, don't be so sad. But go ahead and cry if you want. Pap Nicky will dry your eyes and blow your nose." He offered her the curve of his arm. She crept into it, buried her face against his side, and wept herself to sleep.

Kusulongo the Mountain rose monstrous from the plain, cliff upon gloomy cliff, with talus slopes and glaciers between, until the spires carved from its top stood ragged across the sun disk. Joyce had seldom felt the cold and murk of this world as she did now, riding up the path to the city on a horned animal that must be blanketed against the human warmth of her suit. The wind went shrieking through the empty dark sky, around the crags, to buffet her like fists and snap the banner which Uulobu carried on a lance as he rode ahead. Glancing back, down a dizzying sweep of stone, she saw Nyaronga and the half-dozen other chiefs who had been allowed to come with the party. Their crests and cloaks streamed about them; spears rose and fell with the gait of their mounts; the color of their fur was lost in this dreary light, but she thought she made out the grimness on their faces. Immensely far below, at the mountain's foot, lay their followers, five hundred armed and angry Rokulela. But they were hidden by dusk, and if she died on the heights they could give her no more than a vengeance she didn't want.

She shuddered and edged her *basai* close to the one which puffed and groaned beneath van Rijn's weight. Their knees touched. "At least we have some company," she said, knowing the remark was moronic but driven to say anything that might drown out the wind. "Thank God the flare died away so fast."

"*Ja*, we made good time," the merchant said. "Only three days from the Lubambaru to here, that's quicker than I forewaited. And lots of allies picked up."

She harked back wistfully to the trek. Van Rijn had spent the time being amusing, and had succeeded better than she would have expected. But then they arrived, and the Shanga scrambled up the mountain one jump ahead of the Rokulela charge; the attackers withdrew, unwilling to face cannon if there was a chance of avoiding it; a parley was agreed on; and she couldn't imagine how it might end other than in blood. The Ancients might let her group go down again unhurt, as they'd promised—or might not—but however that went, before sundown many warriors would lie broken for the carrion fowl. *Oh, yes,* she admitted to herself, *I'm also afraid of what will happen to me, if I should get back alive to Esperance. Instigating combat! Ten years' corrective detention if I'm lucky . . . unless I run away with Nick and never see home again, never, never—But to make those glad young hunters die!*

She jerked her reins, half minded to flee down the trail and into the desert. The beast skittered under her. Van Rijn caught her by the shoulder. "Calm, there, if you please," he growled. "We has got to outbluff them upstairs. They will be a Satan's lot harder to diddle than the barbarians was."

"Can we?" she pleaded. "They can defend every approach. They're stocked for a long siege, I'm certain, longer than . . . than we could maintain."

"If we bottle them for a month, is enough. For then comes the League ship."

"But they can send for help, too. Use the heliographs." She pointed to one of the skeletal towers above. Its mirror shimmered dully in the red luminance. Only a t'Kelan could see the others, spaced out in several directions across the plains and hills. "Or messengers can slip between our lines—we'd be spread so terribly thin —they could raise the whole Yagola Horde against us."

"Maybe so, maybe not. We see. Now let me think."

They jogged on in silence, except for the wind. After an hour they came to a wall built across the trail. Impassable slopes of detritus stretched on either side. The archway held two primitive cannon. Four members of the city garrison poised there, torches flickering near the fuses. Guards in leather helmets and corselets, armed with bows and pikes, stood atop the wall. The iron gleamed through the shadows.

Uulobu rode forth, cocky in the respect he had newly won from the clans. "Let pass the mighty sky-folk who have condescended to speak with your patriarchs," he demanded.

"Hmpf!" snorted the captain of the post. "When have the sky-folk ever had the spirit of a gutted *yangulu?*"

"They have always had the spirit of a *makovolo* in a rage," Uulobu said. He ran a thumb along the edge of his dagger. "If you wish proof, consider who dared cage the Ancients on their own mountain."

The warrior made a flustered noise, collected himself, and stated loudly, "You may pass, then, and be safe as long as the peace between us is not unsaid."

"No more fiddlydoodles there," van Rijn rapped. "We want by, or we take your popguns and stuff them in a place they do not usually go." Joyce forebore to interpret. Nick had so many good qualities; if only he could overcome that vulgarity! But he had had a hard life,

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poor thing. No one had ever really taken him in hand . . . Van Rijn rode straight between the cannon and on up the path.

It debouched on a broad terrace before the city wall. Other guns frowned from the approaches. Two score warriors paced their rounds with more discipline than was known in the Hordes. Joyce's eyes went to the three shapes in the portal. They wore plain white robes, and their crests were grizzled with age. But their gaze was arrogant on the newcomers.

She hesitated. "I . . . this is the chief scribe—" she began.

"No introduction to secretaries and office boys," van Rijn said. "We go straight to the boss."

Joyce moistened her lips and told them: "The head of the sky-folk demands immediate parley."

"So be it," said one Ancient without tone. "But you must leave your arms here."

Nyaronga bared his teeth. "There is no help for it," Joyce reminded him. "You know as well as I, by the law of the fathers, none but Ancients and warriors born in the city may go through this gate with weapons." Her own holster and van Rijn's were already empty.

She could almost see the heart sink in the Rokulela, and remembered what the Earthman had said about instinct. Disarming a t'Kelan was a symbolic emasculation. They put a bold face on it, clattering their implements down and dismounting to stride with stiff backs at van Rijn's heels. But she noticed how their eyes flickered about, like those of trapped animals, when they passed the gateway.

Kusulongo the City rose in square tiers, black and massive under the watchtowers. The streets were narrow guts twisting between, full of wind and the noise of hammering from the metalsmiths' quarters. Dwellers by birthright stood aside as the barbarians passed, drawing their robes about them as if to avoid contact. The three councilors said no word, and stillness fell everywhere as they walked deeper into the citadel, until Joyce wanted to scream.

At the middle of the city stood a block full twenty meters high, windowless, only the door and the ventholes opening to air. Guards hoisted their swords and hissed in salute as the hierarchs went through the entrance. Joyce heard a small groan at her back. The Rokulela followed the humans inside, down a winding hall, but she didn't think they would be of much use. The torchlit cave at the end was cleverly designed to sap a hunter's nerve.

Six white-robed oldsters were seated on a semicircular dais. The wall behind them carried a mosaic, vivid even in this fluttering dimness, the sun as it flared. Nyaronga's breath sucked between his teeth. He had just been reminded of the Ancients' power. True, Joyce told herself, he knew the humans could take over the same functions. But immemorial habit is not easily broken.

Their guides sat down, too. The newcomers remained standing. Silence thickened. Joyce swallowed several times and said: "I speak for Nicholas van Rijn, patriarch of the sky-folk, who has leagued himself with the Rokulela clans. We come to demand justice."

"Here there is justice," the white-crested male at the center of the dais replied. "I, Oluba's son Akulo, Ancient born, chief in council, speak for Kusulongo the City. Why have you borne a spear against us?"

"Ha!" snorted van Rijn when it had been conveyed to him. "Ask that old hippopotamus why he started these troubles in the first place."

"You mean hypocrite," Joyce said automatically.

"I mean what I mean. Come on, now. I know very well why he has, but let us hear what ways he covers up."

Joyce put the question. Akulo curled his tendrils, a gesture of skepticism, and murmured, "This is strange. Never have the Ancients taken part in quarrels below the mountain. When you attacked the Shanga, we gave them refuge, but such is old custom. We will gladly hear your dispute with them and arrange a fair settlement, but this is no fight of ours."

Joyce anticipated van Rijn by snapping in an upsurge of indignation: "They blew down our walls. Who could have supplied them the means but yourselves?"

"Ah, yes." Akulo stroked his whiskers. "I understand your thinking, sky-female. It is very natural. Well, as this council intended to explain should other carriers of your people arrive here and accuse us, we do sell fireworks for magic and celebration. The Shanga bought a large quantity from us. We did not ask why. No rule controls how much may be bought at a time. They must have emptied the powder out, to use against you."

"What's he say?" van Rijn demanded.

Joyce explained. Nyaronga muttered—it took courage with the Ancients listening— "No doubt the Shanga pride-fathers will support that tale. An untruth is a low price for weapons like yours."

"What weapons speak you of?" a councilor interrupted.

"The arsenal the sky-folk had, which the Shanga captured for use against my own Horde," Nyaronga spat. His mouth curlel upward. "So much for the disinterestedness of the Ancients."

"But— No!" Akulo leaned forward, his voice not quite as smooth as before. "It is true that Kusulongo the City did nothing to discourage an assault on the sky-ones' camp. They are weak and bloodless, legitimate prey. More, they were causing unrest among the clans, undermining the ways of the fathers—"

"Ways off which Kusulongo the City grew fat," Joyce put in.

Akulo scowled at her but continued addressing Nyaronga: "By their attack, the Shanga did win a rich plunder of metal. They will have many good knives. But that is not enough addition to their power that they

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could ever invade new lands when desperation does not lash them. We thought of that, too, here on the mountain, and did not wish to see it happen. The concern of the Ancients was ever to preserve a fitting balance of things. If the sky-folk went away, that balance would actually be restored which they endangered. A little extra metal in Yagola hands would not upset it anew. The sky-folk were never seen to carry any but a few hand weapons. Those they took with them when they fled. There never was an armory in the dome for the Shanga to seize. Your fear was for nothing, you Rokulela."

Joyce had been translating for van Rijn *sotto voce*. He nodded. "Hokay. Now tell them what I said you should."

I've gone too far to retreat, she realized desolately. "But we did have weapons in reserve!" she blurted. "Many of them, hundreds, whole boxes full, that we did not get a chance to use before the attack drove us outside.

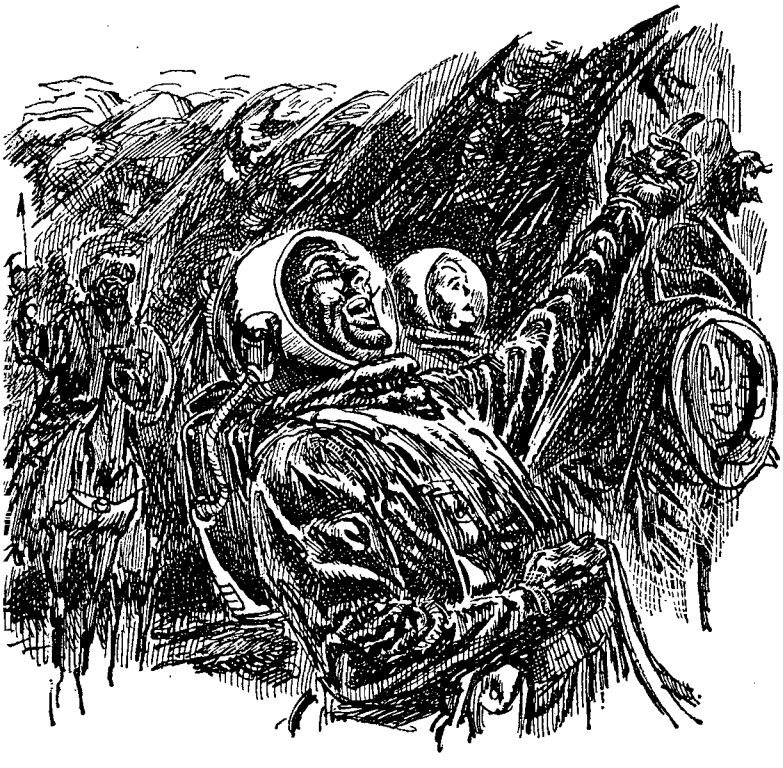
Silence cracked down. The councilors stared at her in horror. Torch flames jumped and shadows chased each other across the walls. The Rokulela chiefs watched with a stern satisfaction that put some self-confidence back into them.

Finally Akulo stuttered, "B-b-but you said . . . I asked you once myself, and you denied having . . . having more than a few—"

"Naturally," Joyce said, "we kept our main strength in reserve, unrevealed."

"The Shanga reported nothing of this sort."

"Would you expect them to?" Joyce let that sink in before she went on. "Nor will you find the cache if you search the oasis. They did not resist our assault with fire, so the guns cannot have been in this neighborhood. Most likely someone took them away at once into the Yagola lands, to be distributed later."



"We shall see about this," clipped another Ancient. "Guard!" A sentry came in through the doorway to the entry tunnel. "Fetch the spokesman of our clan guests."

Joyce brought van Rijn up to date while they waited. "Goes well so far," the merchant said. "But next comes the ticklish part, not so much fun as tickling you."

"Really!" She drew herself up, hot in the face. "You're impossible."

"No, just improbable . . . Ah, here we go already."

A lean t'Kelan in Shanga garb trod into the room. He folded his arms and glowered at the Rokulela. "This is Batuzi's son Masotu," Akulo introduced. He leaned forward, tense as his colleagues. "The sky-folk have said you took many terrible weapons from their camp. Is that truth?"

Masotu started. "Certainly not! There was nothing but that one emptied handgun I showed you when you came down at dawn."

"So the Ancients were indeed in league with the Shanga," rasped a t'Kelan in van Rijn's party.

Briefly disconcerted, Akulo collected himself and said in a steel tone, "Very well. Why should we deny it, after all? Kusulongo the City seeks the good of the whole world, which is its own good; and these sly strangers were bringing new ways that rotted old usage. Were they not softening you for the invasion of their own people? What other reason had they to travel about in your lands? What other reason could they have? Yes, this council urged the Shanga to wipe them out as they deserve."

Though her heartbeat nearly drowned her words, Joyce managed to interpret for van Rijn. The merchant's lips thinned. "Now they confess it to our facing," he said. "Yet they have got to have some story ready to fob off Earth ships and make humans never want to come here again. They do not intend to let us go down this hill alive, I see, and talk contradictions afterwards." But he gave her no word for the natives.

Akulo pointed at Masotu. "Do you tell us, then, that the sky-folk have lied and you found no arsenal?"

"Yes." The Shanga traded stares with Nyaronga. "Ah, your folk fretted lest we use that power to overrun your grasslands," he deduced shrewdly. "There was no need to fear. Go back in peace and let us finish dealing with the aliens."

"We never *feared*," Nyaronga corrected. Nonetheless his glance toward the humans was doubtful.

An ancient stirred impatiently on the dais. "Enough of this," he said. "Now we have all seen still another case of the sky-folk brewing trouble. Call in the guards to slay them, let peace be said between Shanga and all Rokulela, send everyone home, and have done."

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Joyce finished her running translation as Akulo opened his mouth. "Botulism and bureaucrats!" van Rijn exploded. "Not this fast, little chum." He reached under the recycler tank on his back and pulled out his blaster. "Please to keep still."

No t'Kelan stirred, though a hiss went among them. Van Rijn backed toward the wall so he could cover the doorway as well. "Now we talk more friendly," he smiled.

"The law has been broken," Akulo sputtered.

"Likewise the truce which you said between us," Joyce answered, though no culture on this planet regarded oath-breaking as anything but a peccadillo. She felt near fainting with relief. Not that the blaster solved many problems. It wouldn't get them out of a city aswarm with archers and spearcasters. But—

"Quiet!" boomed van Rijn. Echoes rang from wall to stony wall. A couple of sentries darted in. They pulled up short when they saw the gun.

"Come on, join the party," the Earthman invited. "Lots of room and energy charges for everybodies."

To Joyce: "Hokay, now is where we find out whether we have brains enough to get out of being heroes. Tell them that Nicholas van Rijn has a speech to make, then talk for me as I go along."

Weakly, she relayed the message. The least relaxation showed on the tigery bodies before her. Akulo, Nyaronga, and Masotu nodded together. "Let him be heard," the Ancient said. "There is always time to fight afterward."

"Good." Van Rijn's giant form took a step forward. He swept the blaster muzzle around in an oratorical gesture. "First, you should know I caused all this jullaballoo mainly so we could talk. If I come back here alone, you would have clobbered me with pointy little rocks, and that would not be so good for any of us. Ergo, I had to come in company. Let Nyaronga tell you I can fight like a hungry creditor if needful. But maybe there is no need this time, ha?"

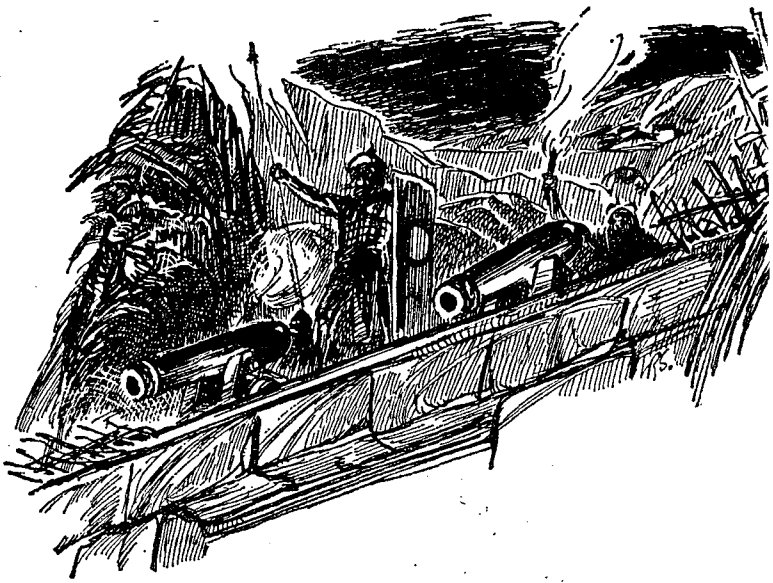
Joyce passed on his words, sentence by sentence, and waited while the Gangu pride-father confirmed that humans were tough customers. Van Rijn took advantage of the general surprise to launch a quick verbal offensive:

"We have got this situation. Suppose the Shanga are lying and have really coppered a modern arsenal. Then they can gain such power that even this city becomes a client of theirs instead of being *primus inter pares* like before. *Nie?* To prevent this, a common cause is needful between Ancients, Rokulela, and us humans who can get bigger weapons to stop the Yagola when our rescue ship comes in."

"But we have no such booty," Masotu insisted.

"So you say," Joyce replied. She was beginning to get van Rijn's general idea. "Ancients and Rokulela, dare you take his word on so weighty a matter?"

As indecision waxed on the dais, van Rijn continued:



"Now let us on the other hands suppose I am the liar and there never was any loose zappers in the dome. Then Shanga and Ancients must keep on working together. For my people's ship that will come from our own territory, which is the whole skyful of stars, they must be told some yarn about why their dome was destroyed. Everybody but me and this cute doll here got safe away, so it will be known the Shanga did the job. Our folks will be angry at losing such a good chance for profit they have been working on for a long time. They will blame the Ancients as using Shanga for pussyfoots, and maybe blow this whole mountain to smitherlets, unless a good story that Shanga corroborate in every way has been cooked beforehand to clear the Ancients. Right? *Ja.* Well, then, for years to come, the Shanga—through them, all Yagola—must be in close touch with Kusulongo town. And they will not take the blame for no payment at all, will they? So hokay, you Rokulela, how impartial you think the Ancients will be to you? How impartial can the Ancients be, when the Shanga can blackmail them? You need humans here to make a balance."

Uulobu clashed his teeth together and cried, "This is true!" But Joyce watched Nyaronga. The chief pondered a long while, trading looks with his colleagues, before he said, "Yes, this may well be. At least, one does not wish to risk being cheated, when disputes come here for judgment. Also, the bad years may come to Yagolaland next, when they must move elsewhere . . . and a single failure to predict a flare for us could weaken our whole country for invasion."

Stillness stretched. Joyce's phone pickup sent her only the sputter of torches and the boom of wind beyond the doorway. Akulo stared down van Rijn's gun muzzle, without a move. At last he said: "You sow discord with great skill, stranger. Do you think we can let you, or these pride-fathers, leave here alive?"

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"*Ja,*" answered van Rijn complacently through Joyce. "Because I did not really stir up trouble, only prove to your own big benefits that you can't trust each other and need human peoples to keep order. For see you, with humans and their weapons around, who have an interest in peace between clans and Hordes, some Yagola with a few guns can't accomplish anything. Or if they truly don't have guns, there is still no reason for the city to work foot in shoe with them if humans return peacefully and do not want revenge for their dome. So either way, the right balance is restored between herders and town. Q.E.D."

"But why should the sky-folk wish to establish themselves here?" Akulo argued. "Is your aim to take over the rightful functions of Kusulongo the City? No, first you must slay each one of us on the mountain!"

"Not needful," van Rijn said. "We make our profit other ways. I have asked out the lady here about the facts while we was en route, and she dovetails very pretty, let me tell you. Uh . . . Joyce . . . you take over now. I am not sure how to best get the notion across when they haven't much chemical theory."

Her mouth fell open. "Do you mean—Nick, do you have an answer?"

"*Ja, ja, ja.*" He rubbed his hands and beamed. "I worked that out fine. Like follows: My own company takes over operations on t'Kela. You Esperancers help us get started, natural, but after that you can go spend your money on some other planet gone to seed . . . while Nicholas van Rijn takes money out of this one."

"What, what are you thinking?"

"Look, I want *kungu* wine, and a fur trade on the side might also be nice to have. The clans everywhere will bring me this stuff. I sell them ammonia and nitrates from the nitrogen-fixing plants we build, in exchange. They will need this to enrich their soils—also they will need to cultivate nitrogen-fixing bacteria the way you show them—to increase crop yields so they can buy still more ammonia and nitrates. Of course, what they will really do this for is to get surplus credit for buying modern gadgets. Guns, especial. Nobody with hunter instincts can resist buying guns; he will even become a part-time farmer to do it. But also my factors will sell them tools and machines and stuff, what makes them slowly more civilized the way you want them to be. On all these deals, Solar Spice & Liquors turns a pretty good profit."

"But we didn't come to exploit them!"

Van Rijn chuckled: "Maybe you Esperancers didn't, but I sure did. And don't you see, this they can understand, the clans. Charity is outside their instincts, but profit is not, and they will feel good at how they swindle us on the price of wine. No more standoffishness and suspicion about humans—not when humans is plainly come here on a money hunt. You see?"

She nodded, half dazed. They weren't going to like this on Esperance; the Commonalty looked down from a lofty moral position on the Polesotechnic League; but they weren't fanatical about it, and if this was the only way the job could be done—Wait. "The Ancients," she objected. "How will you conciliate them? Introducing so many new elements is bound to destroy the basis of their whole economy."

"Oh, I already got that in mind. We will want plenty of native agents and clerks, smart fellows who keep records and expand our market territory and cetera. That takes care of many young Ancients . . . silly name . . . As for the rest, though, maintaining the power and prestiges of the city as a unit, that we can also do. Remember, there are oil wells to develop and electrolysis plants to build. The electrolyzer plants will sell hydrogen to the ammonia plants, and the oil burning operation can sell electricity. Hokay, so I build these oil and electrolyzer plants, turn them over to the Ancients to run, and let the Ancients buy them from me on a long-term mortgage. So profitable and key facilities should suit them very well, *nie?*" He stared thoughtfully into a dark corner. "Um-m-m . . . do you think I can get twenty per cent interest, compounded annual, or must I have to settle for fifteen?"

Joyce gasped a while before she could start searching for Kusulongo phrases.

They went down the mountain toward sunset, with cheers at their back and campfires twinkling below to welcome them. Somehow the view seemed brighter to Joyce than ever erenow. And there was beauty in that illimitable westward plain, where a free folk wandered through their own lives. *The next few weeks, waiting for the ship, won't be bad at all,* she thought.

"Another advantage," van Rijn told her smugly, "is that making a commercial operation with profit for everybody out of this is a much better guarantee the job will be continued for long enough to save the planet. You thought your government could do it. Bah! Governments is dayflies. Any change of ideology, of mood even, and poof goes your project. But private action, where everybody concerned is needful to everybody else's income, that's stable. Politics, they come and go, but greed goes on forever."

"Oh, no, that can't be," she denied.

"Well, we got time in the car to argue about it, and about much else," van Rijn said. "I think I can rig a little still to get the alcohol out of *kungu.* Then we put it in fruit juice and have a sort of wine with our meals like human beings, by damn!"

"I . . . I shouldn't, Nicky . . ."

"You is only young once. You mean a poor old man like me has got to show you how to be young?"

Joyce looked away, flushing. She'd have to maintain a strict watch on him till the ship arrived, she thought. And on herself, for that matter.

Of course, if she did relax just the littlest bit—after all, he really was a very interesting person— ■

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HAM SANDWICH

It gets difficult to handle the problem of a man who has a real talent that you need badly—and he cannot use it if he knows it's honest!

by JAMES H. SCHMITZ

ILLUSTRATED BY LEO SUMMERS

There was no one standing or sitting around the tastefully furnished entry hall of the Institute of Insight when Wallace Cavender walked into it. He was almost half an hour late for the regular Sunday night meeting of advanced students; and even Mavis Greenfield, Dr. Ormond's secretary, who always stayed for a while at her desk in the hall to sign in the stragglers, had disappeared. However, she had left the attendance book lying open on the desk with a pen placed invitingly beside it.

Wallace Cavender dutifully entered his name in the book. The distant deep voice of Dr. Aloys Ormond was dimly audible, coming from the direction of the lecture room, and Cavender followed its faint reverberations down a narrow corridor until he reached a closed door. He eased the door open and slipped unobtrusively into the back of the lecture room.

As usual, most of the thirty-odd advanced students present had seated themselves on the right side of the room where they were somewhat closer to the speaker. Cavender started towards the almost vacant rows of chairs on the left, smiling apologetically at Dr. Ormond who, as the door opened, had glanced up without interrupting his talk. Three other faces turned towards Cavender from across the room. Reuben Jeffries, a heavy-set man with a thin fringe of black hair circling an otherwise bald scalp, nodded soberly and looked away again. Mavis Greenfield, a few rows farther up, produced a smile and a reproachful little headshake; during the coffee break she would carefully explain to Cavender once more that students too tardy to take in Dr. Al's introductory lecture missed the most valuable part of these meetings.

From old Mrs. Folsom, in the front row on the right, Cavender's belated arrival drew a more definite rebuke. She stared at him for half a dozen seconds with a coldly severe frown, mouth puckered in disapproval, before returning her attention to Dr. Ormond.

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Cavender sat down in the first chair he came to and let himself go comfortably limp. He was dead-tired, had even hesitated over coming to the Institute of Insight tonight. But it wouldn't do to skip the meeting. A number of his fellow students, notably Mrs. Folsom, already regarded him as a black sheep; and if enough of them complained to Dr. Ormond that Cavender's laxness threatened to retard the overall advance of the group towards the goal of Total Insight, Ormond might decide to exclude him from further study. At a guess, Cavender thought cynically, it would have happened by now if the confidential report the Institute had obtained on his financial status had been less impressive. A healthy bank balance wasn't an absolute requirement for membership, but it helped . . . it helped! All but a handful of the advanced students were in the upper income brackets.

Cavender let his gaze shift unobtrusively about the group while some almost automatic part of his mind began to pick up the thread of Dr. Al's discourse. After a dozen or so sentences, he realized that the evening's theme was the relationship between subjective and objective reality, as understood in the light of Total Insight. It was a well-worn subject; Dr. Al repeated himself a great deal. Most of the audience nevertheless was following his words with intent interest, many taking notes and frowning in concentration. As Mavis Greenfield liked to express it, quoting the doctor himself, the idea you didn't pick up when it was first presented might come clear to you the fifth or sixth time around. Cavender suspected, however, that as far as he was concerned much of the theory of Total Insight was doomed to remain forever obscure.

He settled his attention on the only two students on this side of the room with him. Dexter Jones and Perrie Rochelle were sitting side by side in front-row chairs—the same chairs they usually occupied during these meetings. They were exceptions to the general run of the group in a number of ways. Younger, for one thing; Dexter was twenty-nine and Perrie twenty-three while the group averaged out at around forty-five which happened to be Cavender's age. Neither was blessed with worldly riches; in fact, it was questionable whether the Rochelle girl, who described herself as a commercial artist, even had a bank account. Dexter Jones, a grade-school teacher, did have one but was able to keep it barely high enough to cover his rent and car payment checks. Their value to the Institute was of a different kind. Both possessed esoteric mental talents, rather modest ones, to be sure, but still very interesting, so that on occasion they could state accurately what was contained in a sealed envelope, or give a recognizable description of the photograph of a loved one hidden in another student's wallet. This provided the group with encouraging evidence that such abilities were, indeed, no fable and somewhere along the difficult road to Total Insight might be attained by all.

In addition, Perrie and Dexter were volunteers for what Dr. Aloys Ormond referred to cryptically as "very advanced experimentation." The group at large had not been told the exact nature of these experiments, but the implication was that they were mental exercises of such power that Dr. Al did not wish other advanced students to try them, until the brave pioneer work being done by Perrie and Dexter was concluded and he had evaluated the results . . .

"Headaches, Dr. Al," said Perrie Rochelle. "Sometimes quite bad headaches—" She hesitated. She was a thin, pale girl with untidy arranged brown hair who vacillated between periods of vivacious alertness and activity and somewhat shorter periods of blank-faced withdrawal. "And then," she went on, "there are times during the day when I get to feeling sort of confused and not quite sure whether I'm asleep or awake . . . you know?"

Dr. Ormond nodded, gazing at her reflectively from the little lectern on which he leaned. His composed smile indicated that he was not in the least surprised or disturbed by her report on the results of the week's experiments—that they were, in fact, precisely the results he had expected. "I'll speak to you about it later, Perrie," he told her gently. "Dexter . . . what experiences have you had?"

Dexter Jones cleared his throat. He was a serious young man who appeared at meetings conservatively and neatly dressed and shaved to the quick, and rarely spoke unless spoken to.

"Well, nothing very dramatic, Dr. Al," he said diffidently. "I did have a few nightmares during the week. But I'm not sure there's any connection between them and, uh, what you were having us do."

Dr. Ormond stroked his chin and regarded Dexter with benevolence. "A connection seems quite possible, Dexter. Let's assume it exists. What can you tell us about those mightmares?"

Dexter said he was afraid he couldn't actually tell them anything. By the time he was fully awake he'd had only a very vague impression of what the nightmares were about, and the only part he could remember clearly now was that they had been quite alarming.

Old Mrs. Folsom, who was more than a little jealous of the special position enjoyed by Dexter and Perrie, broke in eagerly at that point to tell about a nightmare *she'd* had during the week and which *she* could remember fully; and Cavender's attention drifted away from the talk. Mrs. Folsom was an old bore at best, but a very wealthy old bore, which was why Dr. Ormond usually let her ramble on a while before steering the conversation back to the business of the evening. But Cavender didn't have to pretend to listen.

From his vantage point behind most of the group, he let his gaze and thoughts wander from one to the other of them again. For the majority of the advanced stu-

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dents, he reflected, the Institute of Insight wasn't really too healthy a place. But it offered compensations. Middle-aged or past it on the average, financially secure, vaguely disappointed in life, they'd found in Dr. Al a friendly and eloquent guide to lead them into the fascinating worlds of their own minds. And Dr. Al was good at it. He had borrowed as heavily from yoga and western mysticism as from various orthodox and unorthodox psychological disciplines, and composed his own system, almost his own cosmology. His exercises would have made conservative psychiatrists shudder, but he was clever enough to avoid getting his flock into too serious mental difficulties. If some of them suffered a bit now and then, it made the quest of Total Insight and the thought that they were progressing towards that goal more real and convincing. And meeting after meetng Dr. Al came up with some intriguing new twist or device, some fresh experience to keep their interest level high.

"Always bear in mind," he was saying earnestly at the moment, "that an advance made by *any* member of the group benefits the group as a whole. Thus, because of the work done by our young pioneers this week I see indications tonight that the group is ready to attempt a new experiment . . . an experiment at a level I frankly admit I hadn't anticipated you would achieve for at least another two months."

Dr. Ormond paused significantly, the pause underlining his words. There was an expectant stirring among the students.

"But I must caution you!" he went on. "We cannot, of course, be certain that the experiment will succeed . . . in fact, it would be a very remarkable thing if it did succed at a first attempt. But if it should, you will have had a rather startling experience! You will have seen a thing generally considered to be impossible!"

He smiled reassuringly, stepping down from the lectern. "Naturally, there will be no danger. You know me well enough to realize that I never permit the group or individuals to attempt what lies beyond their capability."

Cavender stifled a yawn, blinked water from his eyes, watching Ormond walk over to a small polished table on the left side of the room in front of the rows of chairs. On it Mavis Greenfield had placed a number of enigmatic articles, some of which would be employed as props in one manner or another during the evening's work. The most prominent item was a small suitcase in red alligator hide. Dr. Ormond, however, passed up the suitcase, took a small flat wooden plate from the table and returned to the center of the room.

"On this," he said, holding up the plate, "there rests at this moment the air of this planet and nothing else. But in a minute or two—for each of you, in his or her world of subjective reality—something else *will* appear on it."

The students nodded comprehendingly. So far, the experiment was on familiar ground. Dr. Ormond gave them all a good-humored wink.

"To emphasize," he went on, "that we deal here with practical, down-to-earth, *real* matters . . . not some mystical nonsense . . . to emphasize that, let us say that the object each of you will visualize on this plate will be—a ham sandwich!"

There were appreciative chuckles. But Cavender felt a twinge of annoyance. At the moment, when along with fighting off fatigue he'd been trying to forget that he hadn't eaten since noon, Dr. Al's choice looked like an unfortunate one. Cavender happened to be very fond of ham.

"Now here," Ormond continued, putting the plate down, "is where this experiment begins to differ from anything we have done before. For all of us will try to imagine—to visualize as being on this plate—*the same ham sandwich.* And so there will be no conflict in our projections, let's decide first on just what ingredients we want to put into it." He smiled. "We'll make this the finest ham sandwich our collective imagination can produce!"

There were more chuckles. Cavender cursed under his breath, his mouth beginning to water. Suggestions came promptly.

"Mustard?" Dr. Ormond said. "Of course— Not too sharp though, Eleanor?" He smiled at Mrs. Folsom. "I agree! A light touch of delicate salad mustard. Crisp lettuce . . . finely chopped gherkins. Very well!"

"Put it all on rye," Cavender said helplessly. "Toasted rye."

"Toasted rye?" Ormond smiled at him, looked around. "Any objections? No? Toasted rye it shall be, Wally. And I believe that completes our selection."

He paused, his face turning serious. "Now as to that word of caution I gave you. For three minutes each of you will visualize the object we have chosen on the plate I will be holding up before me. You will do this with your eyes open, and to each of you, in your own subjective reality, the object will become, as you know, more or less clearly discernible.

"But let me tell you this. Do not be too surprised if at the end of that time, when the exercise is over, the object *remains visible to you* . . . does not disappear!"

There was silence for a moment. Then renewed chuckles, but slightly nervous ones, and not too many.

Dr. Ormond said sternly, "I am serious about that! The possibility, though it may be small tonight, is there. You have learned that, by the laws of Insight, any image of subjective reality, if it can be endowed with *all* the attributes of objective reality by its human creator, *must* spontaneously become an image in objective reality!

"In this case, our collective ham sandwich, if it were perfectly visualized, could not only be seen by you but felt, its weight and the texture of each of its ingredients perceived, their appetizing fragrance savored"—Cav-

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ender groaned mentally— "and more: if one of you were to eat this sandwich, he would find it exactly as nourishing as any produced by the more ordinary methods of objective reality.

"There are people in the world today," Dr. Ormond concluded, speaking very earnestly now, "Who can do this! There always have been people who could do this. And you are following in their footsteps, being trained in even more advanced skills. I am aware to a greater extent than any of you of the latent power that is developing—has developed—in this group. Tonight, for the first time, that power will be focused, drawn down to a pinpoint, to accomplish one task.

"Again, I do not say that at the end of our exercise a ham sandwich will lie on this plate. Frankly, I don't expect it. But I suggest very strongly that you don't let it surprise or startle you too much if we find it here!"

There was dead stillness when he finished speaking. Cavender had a sense that the lecture room had come alive with eerie little chills. Dr. Ormond lifted the plate solemnly up before him, holding it between the fingertips of both hands.

"Now, if you will direct your attention here . . . no, Eleanor, with your eyes open!

"Let us begin . . ."

Cavender sighed, straightened up in his chair, eyes fixed obediently on the wooden plate, and banned ham sandwiches and every other kind of food firmly from his thoughts. There was no point in working his appetite up any further when he couldn't satisfy it, and he would have to be on guard a little against simply falling asleep during the next three minutes. The cloudiness of complete fatigue wasn't too far away. At the edge of his vision, he was aware of his fellow students across the room, arranged in suddenly motionless rows like staring zombies. His eyelids began to feel leaden.

The three minutes dragged on, came to an end. Ormond slowly lowered his hands. Cavender drew a long breath of relief. The wooden plate, he noted, with no surprise, was still empty.

"You may stop visualizing," Ormond announced.

There was concerted sighing, a creaking of chairs. The students came out of their semitrances, blinked, smiled, settled into more comfortable positions, waiting for Dr. Al's comments.

"No miracles this time!" Ormond began briskly. He smiled.

Mrs. Folsom said, "Dr. Al—"

He looked over at her. "Yes, Eleanor?"

Eleanor Folsom hesitated, shook her head. "No," she said. "Go on. I'm sorry I interrupted."

"That's all right." Dr. Al gave her a warm smile. It had been, he continued, a successful exercise, a very promising first attempt, in spite of the lack of an immediate materialization, which, of course, had been only a remote possibility to start with. He had no fault to find with the quality of the group's effort. He had sensed it . . . as they, too, presently would be able to sense it . . . as a smooth flow of directed energy. With a little more practice . . . one of these days . . .

Cavender stifled one yawn, concealed another which didn't allow itself to be stifled behind a casually raised hand. He watched Ormond move over to the prop table, put the wooden plate down beside the red suitcase without interrupting his encouraging summary of the exercise, hesitate, then pick up something else, something which looked like a flexible copper trident, and start back to the center of the room with it.

Mrs. Folsom's voice said shrilly, "*Dr. Al—!*"

Ormond looked patient.

"Yes, Eleanor? What is it?"

"Just now," Mrs. Folsom said, her voice still holding the shrill note, "just a moment ago, on the plate over there, I'm certain . . . I'm almost certain I saw the ham sandwich!"

She added breathlessly, "And that's what I was going to say before, Dr. Al! Right after you told us to stop visualizing I thought I saw the sandwich on the plate! But it was only for a moment and I wasn't sure. But now I'm sure, almost sure, that I saw it again on the plate on the table!"

The old woman was pointing a trembling finger towards the table. Her cheeks showed spots of hectic red. In the rows behind her, the students looked at one another, shook their heads in resignation, some obviously suppressing amusement. Others looked annoyed. They were all familiar with Eleanor Folsom's tendency to produce such little sensations during the meetings. If the evening didn't promise to bring enough excitement, Eleanor always could be counted on to take a hand in events.

Cavender felt less certain about it. This time, Mrs. Folsom sounded genuinely excited. And if she actually believed she'd seen something materialize, she might be fairly close to getting one of those little heart attacks she kept everyone informed about.

Dr. Al could have had the same thought. He glanced back at the prop table, asked gravely, "You don't see it there now, do you, Eleanor?"

Mrs. Folsom shook her head. "No. No, of course not! It disappeared again. It was only there for a second. But I'm sure I saw it!"

"Now this is very interesting," Ormond said seriously. "Has anyone else observed anything at all unusual during the last few minutes?"

There was a murmured chorus of dissent, but Cavender noticed that the expressions of amusement and annoyance had vanished. Dr. Al had changed the tune, and the students were listening intently. He turned back to Mrs. Folsom.

"Let us consider the possibilities here, Eleanor," he

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said. "For one thing, you should be congratulated in any case, because your experience shows that your visualization was clear and true throughout our exercise. If it hadn't been, nothing like this could have occurred.

"But precisely what was the experience? There we are, as of this moment, on uncertain ground. You saw something. That no one else saw the same thing might mean simply that no one else happened to be looking at the plate at those particular instants in time. I, for example, certainly gave it no further attention after the exercise was over. You *may* then have observed a genuine materialization!"

Mrs. Folsom nodded vigorously. "Yes, I—"

"But," Ormond went on, "under the circumstances, the scientific attitude we maintain at this Institute demands that we leave the question open. For now. Because you might also, you understand, have projected—for yourself only—a vivid momentary impression of the image you had created during our exercise and were still holding in your mind."

Mrs. Folsom looked doubtful. The flush of excitement began to leave her face.

"Why . . . well, yes, I suppose so," she acknowledged unwillingly.

"Of course," Ormond said. "So tonight we shall leave it at that. The next time we engage in a similar exercise . . . well, who knows?" He gave her a reassuring smile. "I must say, Eleanor, that this is a very encouraging indication of the progress you have made!" He glanced over the group, gathering their attention, and raised the trident-like device he had taken from the table.

"And now for our second experiment this evening—"

Looking disappointed and somewhat confused, Eleanor Folsom settled back in her chair. Cavender also settled back, his gaze shifting sleepily to the remaining items on the prop table. He was frowning a little. It wasn't his business, but if the old woman had started to hypnotize herself into having hallucinations, Dr. Al had better turn to a different type of meeting exercises. And that probably was exactly what Ormond would do; he seemed very much aware of danger signals. Cavender wondered vaguely what the red suitcase on the table contained.

There was a blurry shimmer on the wooden plate beside the suitcase. Then something thickened there suddenly as if drawing itself together out of the air. Perrie Rochelle, sitting only ten feet back from the table, uttered a yelp—somewhere between surprise and alarm. Dexter Jones, beside her, abruptly pushed back his chair, made a loud, incoherent exclamation of some kind.

Cavender had started upright, heart hammering. The thing that had appeared on the wooden plate vanished again.

But it had remained visible there for a full two seconds. And there was no question at all of what it had been.

For several minutes, something resembling pandemonium swirled about the walls of the lecture room of the Institute of Insight. The red suitcase had concealed the wooden plate on the prop table from the eyes of most of the students sitting on the right side of the room, but a number of those who could see it felt they had caught a glimpse of something. Of just what they weren't sure at first, or perhaps they preferred not to say.

Perrie and Dexter, however, after getting over their first shock, had no such doubts. Perrie, voice vibrant with excitement, answered the questions flung at her from across the room, giving a detailed description of the ham sandwich which had appeared out of nowhere on the polished little table and stayed there for an incredible instant before it vanished. Dexter Jones, his usually impassive face glowing and animated, laughing, confirmed the description on every point.

On the opposite side of the room, Eleanor Folsom, surrounded by her own group of questioners, was also having her hour of triumph, in the warmth of which a trace of bitterness that her first report of the phenomenon had been shrugged off by everyone—even, in a way, by Dr. Al—gradually dissolved.

Dr. Al himself, Cavender thought, remained remarkably quiet at first, though in the excitement this wasn't generally noticed. He might even have turned a little pale. However, before things began to slow down he had himself well in hand again. Calling the group to a semblance of order, he began smilingly to ask specific questions. The witnesses on the right side of the room seemed somewhat more certain now of what they had observed.

Dr. Ormond looked over at Cavender.

"And you, Wally?" he asked. "You were sitting rather far back, to be sure—"

Cavender smiled and shrugged.

"Sorry, Dr. Al. I just wasn't looking in that direction at the moment. The first suggestion I had that anything unusual was going on was when Perrie let out that wild squawk."

There was general laughter. Perrie grinned and flushed.

"Well, I'd have liked to hear *your* squawk," she told Cavender, "if you'd seen a miracle happen right before your nose!"

"Not a miracle, Perrie," Ormond said gently. "We must remember that. We are working here with natural forces which produce natural phenomena. Insufficiently understood phenomena, perhaps, but never miraculous ones. Now, how closely did this materialization appear to conform to the subjective group image we had decided on for our exercise?"

"Well. I could only see it, of course, Dr. Al. But as far as I saw it, it was exactly what we'd . . . no, wait!" Perrie frowned, wrinkling her nose. "There was something added!" She giggled. "At least, I don't remember

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anyone saying we should imagine the sandwich wrapped in a paper napkin!"

Across the room, a woman's voice said breathlessly, "Oh! A *green* paper napkin, Perrie?"

Perrie looked around, surprised. "Yes, it was, Mavis."

Mavis Greenfield hesitated, said with a nervous little laugh, "I suppose I did that. I added a green napkin after we started the exercise." Her voice quavered for an instant. "I thought the image looked neater that way." She looked appealingly at the students around her. "This is really incredible, isn't it"

They gave her vague smiles. They were plainly still floating on a cloud of collective achievement—if they hadn't created that sandwich, there could have been nothing to see!

It seemed to Cavender that Dr. Ormond's face showed a flicker of strain when he heard Mavis' explanation. But he couldn't be sure because the expression—if it had been there—was smoothed away at once. Ormond cleared his throat, said firmly and somewhat chidingly, "No, not incredible, Mavis! Although—"

He turned on his smile. "My friends, I must admit that you *have* surprised me! Very pleasantly, of course. But what happened here is something I considered to be only a very remote possibility tonight. You are truly more advanced than I'd realized.

"For note this. If even one of you had been lagging behind the others, if there had been any unevenness in the concentration each gave to the exercise tonight, this materialization simply could not have occurred! And that fact forces me now to a very important decision."

He went over to the prop table, took the suitcase from it. "Mavis," he said gravely. "you may put away these other devices. We will have no further need for them in this group! Dexter, move the table to the center of the room for me, please."

He waited while his instructions were hastily carried out, then laid the suitcase on the table, drew up a chair and sat down. The buzz of excited conversation among the students hushed. They stared at him in anticipatory silence. It appeared that the evening's surprises were not yet over—and they were ready for *anything* now!

"There is a point," Dr. Ormond began in a solemn voice, riveting their eager attention on him, "a point in the orderly advance towards Total Insight at which further progress becomes greatly simplified and accelerated, because the student has now developed the capability to augment his personal efforts by the use of certain instruments."

Cavender thoughtfully reached inside his coat, brought out a cigarette case, opened it and slowly put a cigarette to his lips. About to flick on a lighter, he saw Reuben Jeffries watching him with an expression of disapproval from across the aisle. Jeffries shook his head, indicated the NO SMOKING sign on the wall. Cavender nodded, smiling a rueful apology for his absent-mindedness, and returned the cigarette to its case. He shoved his hands into his trousers pockets, slouched back in the chair.

"I have told you," Ormond was saying, "that the contributions many of you so generously made to the Institute were needed for and being absorbed by vital research. Tonight I had intended to give you a first inkling of what that research was accomplishing." He tapped the suitcase on the table before him. "In there is an instrument of the kind I have mentioned. The beneficial forces of the Cosmos are harnessed by it, flow through it. And I believe I can say that my efforts in recent months have produced the most effective such device ever seen . . ."

"Dr. Al," Mrs. Folsom interrupted firmly, "I think you should let them know how the instrument cured my heart condition."

Faces shifted towards her, then back to Dr. Al. The middle-aged majority of the students pricked their ears. For each of them, conscious of the years of increasingly uncertain health to come, Mrs. Folsom's words contained a personal implication, one that hit home. But in spite of the vindication of her claim to have seen a materialized ham sandwich, they weren't quite ready to trust her about this.

Dr. Ormond's face was grave.

"Eleanor," he said reprovingly, "that was letting the cat out of the bag, wasn't it? I hadn't intended to discuss that part of the matter just yet."

He hesitated, frowning, tapping the table top lightly with his knuckles. Mrs. Folsom looked unabashed. She had produced another sensation and knew it.

"Since it was mentioned," Ormond said with deliberation at last, "it would be unfair not to tell you, at least in brief, the facts to which Eleanor was alluding. Very well then—Eleanor has served during the past several weeks as the subject of certain experiments connected with this instrument. She reports that after her first use of it, her periodically recurring heart problem ceased to trouble her."

Mrs. Folsom smiled, nodded vigorously. "I have not," she announced, "had one single touch of pain or dizziness in all this time!"

"But one should, of course," Dr. Ormond added objectively, "hesitate to use the word 'cure' under such circumstances."

In the front row someone asked, "Dr. Al, will the instrument heal . . . well, other physical conditions?"

Ormond looked at the speaker with dignity. "John, the instrument does, and is supposed to do, one thing. Providing, as I've said, that the student working with it has attained a certain minimum level of Insight, it greatly accelerates his progress towards Total Insight. Very greatly!

"Now, as I have implied before: as one approaches the goal of Total Insight, the ailments and diseases

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which commonly afflict humanity simply disappear. Unfortunately, I am not yet free to show you proof for this, although I have the proof and believe it will not be long before it can be revealed at least to the members of this group. For this reason, I have preferred not to say too much on the point . . . Yes, Reuben? You have a question?"

"Two questions, Dr. Al," Reuben Jeffries said. "First, is it your opinion that our group has now reached the minimum level of Insight that makes it possible to work with those instruments?"

Ormond nodded emphatically. "Yes, it has. After tonight's occurrence there is no further question about that."

"Then," Jeffries said, "my second question is simply —*when do we start?*"

There was laughter, a scattering of applause. Ormond smiled, said, "An excellent question, Reuben! The answer is that a number of you will start immediately.

"A limited quantity of the instruments—fifteen, I believe—are available now on the premises, stored in my office. Within a few weeks I will have enough on hand to supply as many of you as wish to speed up their progress by this method. Since the group's contributions paid my research expenses, I cannot in justice ask more from you individually now than the actual cost in material and labor for each instrument. The figure . . . I have it somewhere . . . oh, yes!" Ormond pulled a notebook from his pocket, consulted it, looked up and said, mildly, "Twelve hundred dollars will be adequate, I think."

Cavender's lips twitched sardonically. Three or four of the group might have flinched inwardly at the price tag, but on the whole they were simply too well heeled to give such a detail another thought. Checkbooks were coming hurriedly into sight all around the lecture room. Reuben Jeffries, unfolding his, announced, "Dr. Al, I'm taking one of the fifteen."

Half the students turned indignantly to stare at him. "Now wait a minute, Reuben!" someone said. "That isn't fair! It's obvious there aren't enough to go around."

Jeffries smiled at him. "That's why I spoke up, Warren!" He appealed to Ormond. "How about it, Dr. Al?"

Ormond observed judiciously, "It seems fair enough to me. Eleanor, of course, is retaining the instrument with which she has been working. As for the rest of you—first come, first served, you know! If others would like to have Mavis put down their names . . ."

There was a brief hubbub as this suggestion was acted on. Mavis, Dexter Jones and Perrie Rochelle then went to the office to get the instruments, while Dr. Ormond consoled the students who had found themselves left out. It would be merely a matter of days before the new instruments began to come in . . . and yes, they could leave their checks in advance. When he suggested tactfully that financial arrangements could be made if necessary, the less affluent also brightened up.

Fifteen identical red alligator-hide suitcases appeared and were lined up beside Ormond's table. He announced that a preliminary demonstration with the instrument would be made as soon as those on hand had been distributed. Mavis Greenfield, standing beside him, began to read off the names she had taken down.

Reuben Jeffries was the fifth to come up to the table, hand Ormond his check and receive a suitcase from the secretary. Then Cavender got unhurriedly to his feet.

"Dr. Ormond," he said, loudly enough to center the attention of everyone in the room on him, "may I have the floor for a moment?"

Ormond appeared surprised, then startled. His glance went up to Reuben Jeffries, still standing stolidly beside him, and his face slowly whitened.

"Why . . . well, yes, Wally." His voice seemed unsteady. "What's on your mind?"

Cavender faced the right side of the room and the

questioning faces turned towards him.

"My name, as you know," he told the advanced students, "is Wallace Cavender. What you haven't known so far is that I am a police detective, rank of lieutenant, currently attached to the police force of this city and in temporary charge of its bunco squad."

He shifted his gaze towards the front of the room. Ormond's eyes met his for a moment, then dropped.

"Dr. Ormond," Cavender said, "you're under arrest. The immediate charge, let's say, is practicing medicine without a license. Don't worry about whether we can make it stick or not. We'll have three or four others worked up by the time we get you downtown."

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For a moment, there was a shocked, frozen stillness in the lecture room. Dr. Ormond's hand began to move out quietly towards the checks lying on the table before him. Reuben Jeffries' big hand got there first.

"I'll take care of these for now, Dr. Al," Jeffries said with a friendly smile. "The lieutenant thinks he wants them."

Not much more than thirty minutes later, Cavender unlocked the door to Dr. Ormond's private office, went inside, leaving the door open behind him, and sat down at Ormond's desk. He rubbed his aching eyes, yawned, lit a cigarette, looked about in vain for an ashtray, finally emptied a small dish of paper clips on the desk and placed the dish conveniently close to him.

There had been an indignant uproar about Dr. Al's arrest for a while, but it ended abruptly when uniformed policemen appeared in the two exit doors and the sobering thought struck the students that any publicity given the matter could make them look personally ridiculous and do damage to their business and social standing.

Cavender had calmed their fears. It was conceivable, he said, that the district attorney's office would wish to confer with some of them privately, in connection with charges to be brought against William Fitzgerald Grady —which, so far as the police had been able to establish, was Dr. Ormond's real name. However, their association with the Institute of Insight would not be made public, and any proceedings would be carried out with the discretion that could be fully expected by blameless citizens of their status in the community.

They were fortunate, Cavender went on, in another respect. Probably none of them had been aware of just how much Grady had milked from the group chiefly through quiet private contributions and donations during the two years he was running the Institute. The sum came to better than two hundred thousand dollars. Grady naturally had wasted none of this in "research" and he was not a spendthrift in other ways. Cavender was, therefore, happy to say that around two-thirds of this money was known to be still intact in various bank accounts, and that it would be restored eventually to the generous but misled donors.

Dr. Al's ex-students were beginning to look both chastened and very much relieved. Cavender briefly covered a few more points to eliminate remaining doubts. He touched on Grady's early record as a confidence man and blackmailer, mentioned the two terms he had spent in prison and the fact that for the last eighteen years he had confined himself to operations like the Institute of Insight where risks were less. The profits, if anything, had been higher because Grady had learned that it paid off, in the long run, to deal exclusively with wealthy citizens and he was endowed with the kind of personality needed to overcome the caution natural to that class. As for the unusual experiences about which some of them might be now thinking, these, Cavender concluded, should be considered in the light of the fact that Grady had made his living at one time as a stage magician and hypnotist, working effectively both with and without trained accomplices.

The lecture had gone over very well, as he'd known it would. The ex-students left for their homes, a subdued and shaken group, grateful for having been rescued from an evil man's toils. Even Mrs. Folsom, who had announced at one point that she believed she had a heart attack coming on, recovered sufficiently to thank Cavender and assure him that in future she would take her problems only to a reliable physician.

Footsteps were coming down the short hall from the back of the building. Then Reuben Jeffries' voice said, "Go into the office. The lieutenant's waiting for you there."

Cavender stubbed out his cigarette as Dexter Jones, Perrie Rochelle and Mavis Greenfield filed into the office. Jeffries closed the door behind them from the hall and went off.

"Sit down," Cavender said, lighting a fresh cigarette.

They selected chairs and settled down stiffly, facing him. All three looked anxious and pale; and Perrie's face was tear-stained.

Cavender said, "I suppose you've been wondering why I had Sergeant Jeffries tell you three to stay behind."

Perrie began, her eyes and voice rather wild, "Mr. Cavender . . . Lieutenant Cavender . . ."

"Either will do," Cavender said.

"Mr. Cavender, I swear you're wrong! We didn't have anything to do with Dr. Al's . . . Mr. Grady's cheating those people! At least, I didn't. I swear it!"

"I didn't say you had anything to do with it, Perrie," Cavender remarked. "Personally I think none of you had anything to do with it. Not voluntarily, at any rate."

He could almost feel them go limp with relief. He waited. After a second or two, Perrie's eyes got the wild look back. "But . . ."

"Yes?" Cavender asked.

Perrie glanced at Dexter Jones, at Mavis.

"But then what *did* happen?" she asked bewilderedly, of the other two as much as of Cavender. "Mr. Cavender, I saw something appear on that plate! I know it did. It was a sandwich. It looked perfectly natural. I don't think it could have *possibly* been something Mr. Grady did with mirrors. And how could it have had the paper napkin Mavis had just been thinking about wrapped around it, unless . . ."

"Unless it actually was a materialization of a mental image you'd created between you?" Cavender said. "Now settle back and relax, Perrie. There's a more reasonable explanation for what happened tonight than that."

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He waited a moment, went on. "Grady's one real interest is money and since none of you have any to speak of, his interest in you was that you could help him get it. Perrie and Dexter showed some genuine talent to start with, in the line of guessing what card somebody was thinking about and the like. It's not too unusual an ability, and in itself it wasn't too useful to Grady.

"But he worked on your interest in the subject. All the other students, the paying students, had to lose was a sizable amount of cash . . . with the exception of Mrs. Folsom who's been the next thing to a flip for years anyway. She was in danger. And you three stood a good chance of letting Grady wreck your lives. I said he's a competent hypnotist. He is. Also a completely ruthless one."

He looked at Mavis. "As far as I know, Mavis, you haven't ever demonstrated that you have any interesting extrasensory talents like Dexter's and Perrie's. Rather the contrary. Right?"

She nodded, her eyes huge.

"I've always tested negative. Way down negative. That's why I was really rather shocked when that . . . Of course, I've always been fascinated by such things. And *he* insisted it would show up in me sometime."

"And," Cavender said, "several times a week you had special little training sessions with him, just as his two star pupils here did, to help it show up. You were another perfect stooge, from Grady's point of view. Well, what it amounts to is that Grady was preparing to make his big final killing off this group before he disappeared from the city. He would have collected close to thirty thousand dollars tonight, and probably twice as much again within the next month or so before any of the students began to suspect seriously that Dr. Al's instruments could be the meaningless contraptions they are.

"You three have been hypnotically conditioned to a fare-you-well in those little private sessions you've had with him. During the past week you were set up for the role you were to play tonight. When you got your cue—at a guess it was Mrs. Folsom's claim that *she'd* seen the ham sandwich materialize—you started seeing, saying, acting, and thinking exactly as you'd been told to see, say, act, and think. There's no more mystery about it than that. And in my opinion you're three extremely fortunate young people in that we were ready to move in on Grady when we were."

There was silence for a moment. Then Perrie Rochelle said hesitantly, "Then Mrs. Folsom . . ."

"Mrs. Folsom," Cavender said, "has also enjoyed the benefits of many private sessions with Grady. She, of course, was additionally paying very handsomely for them. Tonight, she reported seeing what she'd been told to report seeing, to set off the hypnotic chain reaction."

"But," Perrie said, "she said her heart attacks stopped after she started using the instrument. I really don't see how that could have been just her imagination?"

"Very easily," Cavender said. "I've talked with her physician. Mrs. Folsom belongs to a not uncommon type of people whose tickers are as sound as yours or mine, but who are convinced they have a serious heart ailment and can dish up symptoms impressive enough to fool anyone but an informed professional. They can stop dishing them up just as readily if they think they've been cured." He smiled faintly. "You look as if you might be finally convinced, Perrie."

She nodded. "I . . . yes, I guess so. I guess I am."

"All right," Cavender said. He stood up. "You three can run along then. You won't be officially involved in this matter, and no one's going to bother you. If you want to go on playing around with E.S.P. and so forth, that's your business. But I trust that in future you'll have the good sense to keep away from characters like Grady. Periods of confusion, chronic nightmares—even chronic headaches—are a good sign you're asking for bad trouble in that area."

They thanked him, started out of the office in obvious relief. At the door, Perrie Rochelle hesitated, looked back.

"Mr. Cavender . . ."

"Yes?"

"You don't think I . . . I need . . ."

"Psychiatric help? No. But I understand," Cavender said, "that you have a sister in Maine who's been wanting you to spend the summer with her. I think that's a fine idea! A month or two of sun and salt water is exactly what you can use to drive the last of this nonsense out of your mind again. So good night to the three of you, and good luck!"

Cavender snapped the top of the squat little thermos flask back in place and restored it to the glove compartment of Jeffries' car. He brushed a few crumbs from the knees of his trousers and settled back in the seat, discovering he no longer felt nearly as tired and washed out as he had been an hour ago in the lecture room. A few cups of coffee and a little nourishment could do wonders for a man, even at the tail end of a week of hard work.

The last light in the Institute building across the street went out and Cavender heard the click of the front door. The bulky figure of Detective Sergeant Reuben Jeffries stood silhouetted for a moment in the street lights on the entrance steps. Then Jeffries came down the steps and crossed the street to the car.

"All done?" Cavender asked.

"All done," Jeffries said through the window. He opened the door, eased himself in behind the wheel and closed the door.

"They took Grady away by the back entrance," he told Cavender. "The records in his files . . . he wasn't keeping much, of course . . . and the stuff in the safe and those instruments went along with him. He was

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very co-operative. He's had a real scare."

Cavender grunted. "He'll get over it."

Jeffries hesitated, said, "I'm something of a Johnny-come-lately in this line of work, you know. I'd be interested in hearing how it's handled from here on."

"In this case it will be pretty well standard procedure," Cavender said. "Tomorrow around noon I'll have Grady brought in to see me. I'll be in a curt and bitter mood—the frustrated honest cop. I'll tell him he's in luck. The D. A.'s office has informed me that because of the important names involved in this fraud case, and because all but around forty thousand dollars of the money he collected in this town have been recovered, they've decided not to prosecute. He'll have till midnight to clear out. If he ever shows up again, he gets the book."

"Why leave him the forty thousand?" Jeffries asked. "I understood they know darn well where it's stashed."

Cavender shrugged. "The man's put in two years of work, Reuben. If we clean him, he might get discouraged enough to get out of the racket and try something else. As it is, he'll have something like the Institute of Insight going again in another city three months from now. In an rea that hasn't been cropped over recently. He's good in that line . . . one of the best, in fact."

Jeffries thoughtfully started the car, pulled out from the curb. Halfway down the block, he remarked, "You gave me the go-ahead sign with the cigarette right after the Greenfield girl claimed she'd put the paper napkin into that image. Does that mean you finally came to a decision about her?"

"Uh-huh."

Jeffries glanced over at him, asked, "Is there any secret about how you're able to spot them?"

"No . . . except that I don't know. If I could describe to anyone how to go about it, we might have our work cut in half. But I can't, and neither can any other spotter. It's simply a long, tedious process of staying in contact with people you have some reason to suspect of being the genuine article. If they are, you know it eventually. But if it weren't that men with Grady's type of personality attract them somehow from ten miles around, we'd have no practical means at present of screening prospects out of the general population. You can't distinguish one of them from anyone else if he's just walking past you on the street."

Jeffries brought the car to a halt at a stop light.

"That's about the way I'd heard it," he acknowledged. "What about negative spotting? Is there a chance there might be an undiscovered latent left among our recent fellow students?"

"No chance at all," Cavender said. "The process works both ways. If they aren't, you also know it eventually—and I was sure of everyone but Greenfield over three weeks ago. She's got as tough a set of obscuring defenses as I've ever worked against. But after the jolt she got tonight, she came through clear immediately."

The light changed and the car started up. Jeffries asked, "You feel both of them can be rehabilitated?"

"Definitely," Cavender said. "Another three months of Grady's pseudoyoga might have ruined them for good. But give them around a year to settle out and they'll be all right. Then they'll get the call. It's been worth the trouble. Jones is good medium grade—and that Greenfield! She'll be a powerhouse before she's half developed. Easily the most promising prospect I've come across in six years."

"You're just as certain about Perrie Rochelle "

"Uh-huh. Protopsi—fairly typical. She's developed as far as she ever will. It would be a complete waste of time to call her. You can't train something that just isn't there."

Jeffries grunted. "Never make a mistake, eh?"

Cavender yawned, smiled. "Never have yet, Reuben! Not in that area."

"How did you explain the sandwich to them—and Greenfield's napkin? They couldn't have bought your stage magic idea."

"No. Told them those were Dr. Al's posthypnotic suggestions. It's the other standard rationalization."

They drove on in silence for a while. Then Jeffries cleared his throat.

"Incidentally," he said. "I should apologize for the slip with the sandwich, even though it turned out to our advantage. I can't quite explain it. I was thinking of other matters at the moment, and I suppose I . . ."

Cavender, who had been gazing drowsily through the windshield, shook his head.

"As you say, it turned out very well, Reuben. Aside from putting the first crack in Mavis Greenfield's defenses, it shook up Dr. Al to the point where he decided to collect as much as he could tonight, cash the checks, and clear out. So he set himself up for the pinch. We probably gained as much as three or four weeks on both counts."

Jeffries nodded. "I realize that. But . . ."

"Well, you'd have no reason to blame yourself for the slip in any case," Cavender went on. "The fact is I'd been so confoundedly busy all afternoon and evening, I forgot to take time out for dinner. When that sandwich was being described in those mouth-watering terms, I realize I was really ravenous. At the same time I was fighting off sleep. Between the two, I went completely off guard for a moment, and it simply happened!"

He grinned. "As described, by the way, it *was* a terrific sandwich. That group had real imagination!" He hesitated, then put out his hand, palm up, before him. "As a matter of fact, just talking about it again seems to be putting me in a mood for seconds . . ."

Something shimmered for an instant in the dim air wrapped in its green tissue napkin, a second ham sandwich appeared. ■

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By JOSEPH GOODAVAGE

REPORT ON CRUCIAL EXPERIMENT NO. 4 JANUARY

ASTRO FORECAST

Heavy snowfall over Sierra Nevada mountains on Jan. 8th will spread into the far Southwest. The temperatures will drop again on the 9th, the 12th and the 20th of January in this section of the nation.

On the 10th to 11th of January, from the Ohio Valley to the southern and eastern shores of the Great Lakes—a severe cold front with high winds will pile snow eastward to the Buffalo, New York, area. An unusual dominating pattern over the Gulf states, which would normally indicate dry and mild temperatures, will be offset to some extent by the intensity of the cold up north. As a criterion, the prevailing low temperatures in the Gulf states on January 11th, 12th and 26th will provide clues as to how far south these freezes will penetrate. . . .

Moderate weather in the Far Western sections of the country will, in eastward transit, harden into a bitterly cold winter in the Great Lakes Region.

A semi-stationary element of high pressure and strong winds, activated on January 4th-5th, will dominate the upper Midwest and intensify eastward through the Ohio Valley.

ACTUAL WEATHER

"The second severe cold wave of the 1962-63 winter overspread the nation during January 9 to 13 . . . it followed several days of mild temperatures west of the Appalachians."

"Blizzard conditions occurred in the West-Central Great Plains on the 10th and 11th. The cold wave reduced temperatures to subzero levels east of the Cascade-Sierra Nevada Mountains to the Great Lakes and the Ohio Valley, and to freezing levels or below at all southern stations from Mobile, Ala. to the Pacific coast. This was the tenth freeze at San Diego, Calif., since 1871. West Yellowstone, Mont. reported —56° and Eagle, Colo., —51° on the 12th. The lowest temperature ever recorded in Arizona, —37°, was reported at Maverick on the 13th, . . . lows of —30° or lower were reported in Idaho, Utah, New Mexico, Wyoming and Minnesota. Some of these were down to —50°. In Texas, the severe cold reduced temperatures to —18° at Dalhart in the Panhandle on the 13th and to +25° in the lower Rio Grande Valley on the 13th and 14th. Some stations in the Panhandle reported their lowest temperatures on record."

"Above normal average temperatures and significant precipitation in the Pacific Northwest. . . Hardest hit were Maine and New Hampshire, where drifting 35-inch snowfall piled to over 20-feet high in eastern and central Maine. The cold air that crossed westward over the Rockies to cause such readings as —44° at Fraser, Colo., also poured over the nation from the Great Plains eastward."

"Blizzard conditions in the northeast moved out slowly and kept cold Canadian air flowing across the Northeast during the first four days of the period."

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We can expect seasonably moderate temperatures this month in the Far West; and warmer temperatures will extend to the higher inlands on January 5th and 6th, 12th and 20th.

Southern routes strongly suggested for long-haul highway transportation after January 15th. Generally northing lows spawning in the Pacific Northwest will continue to center more often over the northern states and veer southeastward over the Rockies.

. . . Prevailing low temperatures on January 11th, 12th and 26th will provide clues as to how far south. . . .

On January 18th: blizzards stemming eastward from upper Mississippi Valley with severe cold wave conditions trailing eastward, but diminishing southward. This frigid air will intensify in the Pittsburgh, Pennsylvania, area and will be a preview . .

The severe cold wave will invade the northern half of the nation from the Dakotas on January 23rd, building to maximum intensity in eastward transit through Chicago, Detroit, Louisville, Pittsburgh, Buffalo and New York late on the 25th and early on the 26th. New England will get the cold blast on the 26th and 27th . . . Heating fuel transportation should be planned to provide excess supplies in northern stockpiles and in areas east of the Appalachians *before* January 23rd. This applies also to Texas and southwestern plains areas. Anticipate transportation delays after that date.

". . . Unseasonably warm west of the Great Lakes. Daytime maxima ranged in the 40s and 50s. Significant precipitation fell along the north Pacific coast in western Washington."

". . . West Michigan battered by high winds and snow squalls . . . situation 'really critical' on the 15th. Subfreezing cold covered the Mississippi River with 2 to 3 inches of ice, bank to bank downstream from the Alton, Ill. dam—first time since dam was built 25 years ago."

"CHICAGO, Jan. 12 (AP)—A blizzard whipped across the midwest today . . . wide-ranging cold cracked records that had stood as long as 86 years. . . . Winter at its worst spanned the continent . . . —56° at West Yellowstone, Montana . . . frigid zone reaching from west coast to Great Lakes. Denver's —25° broke record for that date. Amarillo, Texas, —9°, Cheyenne, Wyo., —21°; lowest maximum in city's history . . . a cold wave plummeted southward (on the 13th) to the Mexican border. Lubbock, Texas, 16 degrees below zero, an all-time record low temperature . . . bitter cold wave endangers citrus and vegetable crops . ."

"The storm of the 18th-21st produced blizzard conditions, giving a more permanent snow cover to the Great Plains and Rocky Mountains. . . . A fresh surge of arctic air pushed its way into the North-Central states on the 18th-19th. On the 20th, a wind-lashed snowstorm off Lake Erie, gusts up to 50 m.p.h. whipped snow into blinding clouds . ."

". . . Fifteen below zero in Chicago—lowest in 12 years . . . International Falls, Minn., —38°; Duluth, —30°; Bismark, N.D., —15°. Temperatures plunged along Canadian border on the 22nd as another blizzard swept through midwestern plains and prairies. Tremendous drifts of snow blotting out long stretches of highway . . . winds up to 50 m.p.h. January 23rd: —26° in St. Paul, Minn. Chicago, —18°. Black River Falls, Wisc.; —44° . . . huge ice gorge on the Mississippi River . . . 30 inches of snow at Muskegon, Mich. in 5 days. Ten inches on the 22nd alone. St. Louis, —10°, coldest in 23 years. . . . death toll over 200 across nation, Jan. 24th: 4° in NYC; —30° in Tenn. & Ky.; —21° in Cleveland and Akron; —19° in Pittsburgh; —10° in Buffalo; —12° in Detroit; —3° in Atlanta, Ga., the coldest since 1899. . . . 7″ of snow in Cleveland; 12″ in Buffalo; 54″ in Watertown, N.Y. . . . USWB freeze forecast in S. Florida did not materialize . . . high of 85° in Miami . . . Nome, Alaska, reported warmest winter in 50 years! . . . Crop damage in Rio Grande Valley . . . S. Calif. reported freezing weather for 9th consecutive day . . . Mississippi & Ohio Rivers clogged with ice . . . Missouri River frozen across in many places . . . crop damage of a severe nature reported from California, Arizona and Texas.

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. . . This will herald the *beginning* of a true Deep Freeze . . . Clockwise air flows in eastward transit will generate low pressure areas over Texas and the lower plains as well as in the central Rockies. As a result, expect more precipitation over the center of the nation from Denver eastward.

"On January 24th, weather stations from Ohio southward recorded new all-time record low temperatures:

STATION	*LOWEST*	*PREVIOUS LOW*	
Nashville, Tenn.	−15°	−13°	Feb. 1951
Lexington, Ky.	−21°	−20°	Feb. 1899*
Cleveland, O.	−19°	−17°	Jan. 1873
Cincinnatti, O.	−19°	−17°	Jan. 1936
Toledo, O.	−17°	−16°	Feb. 1899*
Louisville, Ky.	−20°	−20°	Jan. 1884

A low of −34° at Bonnieville, Ky., on the 24th was lowest ever recorded in the state. Previous low, 1899 . . . ground frozen 3 ft. deep in Iowa . . . 10 in. deep in Columbus, O. Lowest temperature of the season reached the lower Rio Grande Valley of Texas on the 24th when readings of 19° and 24° were recorded. Lows of 15 to 18° occurred in the San Antonio and Winter Garden areas . . . little or no precipitation in Far West . . . mountain snowpack remained generally much below normal . . . 4″ to 6″ of snow fell over Ohio Valley & Central Appalachians; 4″ to 8″ over northern Appalachians and much heavier amounts in Michigan, northern N.Y. & Maine. Stations east of Lake Ontario in N.Y. reported 5 feet of new snow and Watertown reported 57 inches on the ground on the morning of the 28th. Snow covered the Great Plains as far south as Kansas and eastward to the Appalachians. Along the Atlntic coast the cover extends from Maine and northern Virginia," . . . et cetera, et cetera.

**February, 1899 was one of the coldest in weather history over the eastern half of the U.S. (Saturn and Uranus were in Sagittarius during the solar eclipse of Jan. 11, 1899).* ■

ADDENDUM

Reports gathered from USWB's "Weekly Weather and Crop Bulletin," Newspapers, LIFE magazine's feature on one of winter's worst blasts in history (Feb. 8 issue)

IN TIMES TO COME

Most of you will, I think, remember Jason dinAlt, the gambler hero of Harry Harrison's story "Deathworld" (January, February and March 1960). Next month Harry is back with a sequel. This time Jason dinAlt is in trouble with a very peculiar type of man and a peculiar type of world indeed.

Mikah was a Good Man—by his own firm assertion; the Good Man, of the sub-class religious fanatic type ultra moral. And the essential character of Jason dinAlt was, like that of most professional gamblers, one of highly flexible morals–which made him naturally the Man Most Unlikely to Succeed in getting along with someone like Mikah.

Dump two inherently conflicting individuals on a world where the culture has disintegrated to bickering city-states inhabited by bickering, jealous clans . . . and Harry Harrison has a perfectly rugged time with the results. Because dinAlt, the man of flexible morals, is a highly ethical man and Mikah, the self-appointed Good man–the ultra moralist–is fanatically unethical.

Also coming up, of course, is the second half of "The Big Fuel Feud" in the article section. In that connection an editorial type comment is perhaps apposite. The quantity of fuel material involved in the propulsion systems of some of the largest present and still larger future rocket systems represent a type of threat that has not been adequately considered either in professional science nor in science fiction. And it is something that science fiction has been markedly remiss in overlooking.

It has recently been pointed out that the uppermost layer of Earth's atmosphere plays an extremely critical role in the dynamics of the entire planet's chemical function. There is very little total mass of ozone, for example, in those uppermost layers–yet that small total tonnage of ozone screens Earth's living things from the more deadly band of solar ultra violet. Big as Earth is those outer fringes have so low a density that the total tonnage is of the same order of magnitude as the tonnage involved in major rocket engine fuel supplies. A major rocket engine's exhaust discharged in those levels could massively alter the balance of molecular types available in the ionosphere (critical to radio communication) and in the screening function of the upper atmosphere. The solid fuel in particular involves atomic species that practically never appear at that level normally–aluminum, zirconium, titanium and magnesium metal particles. It has already been shown that a few pounds of metallic sodium vapor can produce a bright, glowing cloud.

Optical astronomers, radio communication engineers and biologists alike have a direct professional interest in this fuel problem–and all of us, of course, have a personal stake in anything that affects the biosphere of Earth ■ THE EDITOR.

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THE BIG FUEL FEUD

Continued from page 16

cellulose and nitroglycerine are very powerful explosives, but both are unsafe for general use. Guncotton, a highly nitrated nitrocellulose, is very sensitive, unreliable, and dangerous when dry. It loses its sensitivity when wet with water, but it also loses its value as an explosive. Nitroglycerine is more powerful, and even more sensitive than guncotton. It is so unstable that at the slightest provocation, such as a mechanical shock, a little rise in temperature, or a hard look, it changes—almost instantaneously—from a nice, oily liquid to a number of assorted gases that occupy approximately ten thousand times the volume of the original nitroglycerine.

In 1863, Alfred Nobel, of Sweden, obtained a patent on a mixture of nitroglycerine and gunpowder. Three years later, he was granted a patent on a mixture of nitroglycerine and clay—which soon became famous as "dynamite." These mixtures, though considerably less powerful than nitroglycerine, were much less sensitive, and could be used for blasting with a reasonable degree of safety. A secondary advantage lay in their being solids—or rather, plastics—which could be molded to shape and handled with greater ease and safety than could the liquid nitroglycerine.

In 1875, while trying to improve his dynamite by finding a better absorbent material for nitroglycerine than the clay he had been using, Nobel decided to try nitrocellulose. The idea turned out to be a good one. When he mixed NG and "collodion" —nitrated cotton—the result was a homogeneous, transparent, elastic gum that was more powerful than dynamite. At the same time, it was much less sensitive to shock, friction, et cetera, and a great deal safer to use than either of its components! The question as to why this is so became the subject of many discussions and arguments over the years. One explanation was that the "wetting" of the NC by the liquid NG desensitized the NC in the same manner as wetting with water, and that the NG, in turn, was rendered less sensitive by having its molecules separated by the rubbery gelatinized NC. This "explosive gelatin" was the forerunner of ballistite, a smokeless gunpowder developed by Nobel in 1889. Cordite, another smokeless powder, developed by two Englishmen named Abel and Dewar at about the same time, was also a nitroglycerine-nitrocllulos formulation.

The main difference between ballistite and cordite was in the methods of their manufacture. Nobel's procedure was to first gelatinize the guncotton with the nitroglycerine, mix thoroughly, then allow to dry. Cordite was made by blending the ingredients by means of acetone, then evaporating the acetone out of the mixture. These two general procedures have been carried over into modern propellant manufacture as *solventless processing* and *solvent* processing, respectively.

The British Army quickly adopted nitroglycerine-nitrocellulose powder. The American and French Armies, however, objected to its excessively high combustion temperature which resulted in severe erosion of gun barrels, so they used "straight" nitrocellulose that had been gelatinized in ether or alcohol, then stabilized by the admixture of diphenylamine to prevent its deterioration in storage. The NG-NC powder and the stabilized NC became known as double- and single-base propellants, respectively.

When engineers began seriously to try to improve the performance of rockets, it was only natural that one of the first things they would work on would be rocket propellants. And it was only natural that the first thing they would think of in connection with improving propellants would be ballistite. And so it was. But, strange

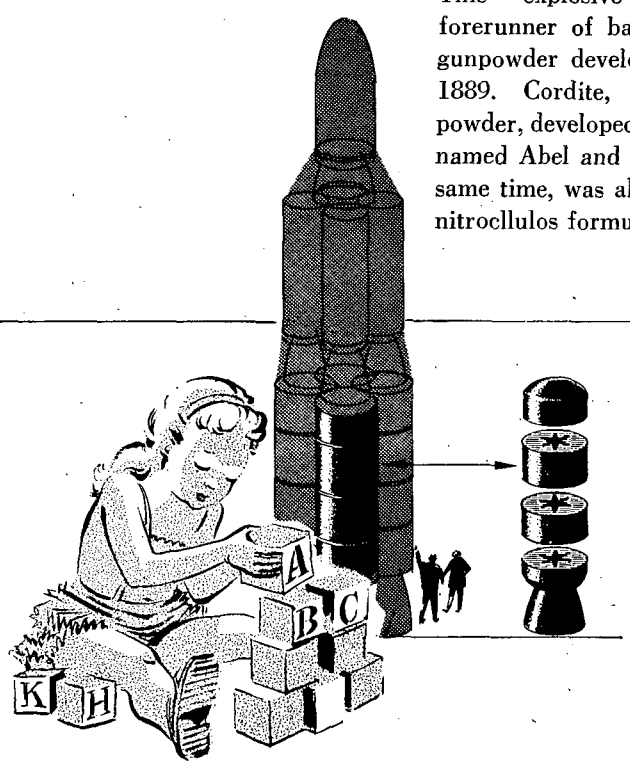

Fig. 6: Illustration of segmented-motor concept. Solid-propellant motors, built on the "building-block" principle, could be made almost any size desired. A number of such motors, clustered as in the illustration, could produce millions of pounds of thrust. A proposal has been made to employ a cluster of segmented motors to place a 350,000-pound satellite in an earth orbit. Such a satellite would be large enough to serve as a manned space station.

Courtesy of Aerojet-General Corporation.

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as it may seem, the first of the new generation of rockets was powered, not by a double-base propellant, but by black powder—modified a little, to be sure, but still black powder. This may seem like throwing overboard everything that had been learned about propellants during the last hundred years, but there was a good reason.

In 1939, the Army Air Corps decided that, to get their heavy-laden bombers off the ground in a shorter distance, they needed more push than their engines could provide. So they sponsored a program to develop an auxiliary power supply in the form of a small rocket engine that could be jettisoned after takeoff. The proposed unit was called "JATO," for Jet-Assisted-Take Off. One of the requirements of a JATO unit was that it produce thrust for a considerable period of time. This, of course, meant that the propellant would have to be slow-burning. The smokeless powders, of both the single and double-base varieties, were powerful, but in 1940 there was no known practical way to slow their burning to the extent necessary to permit their use in a JATO unit.

In 1941, the first American JATO takeoff was accomplished by six units, each of which burned two pounds of black powder. The powder had been molded directly in the combustion chambers in small increments, each of which was subjected to a pressure of twenty tons per square inch. As we—with our 20-20 hindsight—would expect, the system was unreliable and the performance was very low. Not only that, but manufacturing was difficult and time-consuming.

The next development was a radically new concept in propellants. The fuel component was amorphous asphalt, and the oxygen was furnished by potassium perchlorate dispersed in the asphalt matrix. Manufacture of the new propellant was very simple: melt the asphalt by heating, stir in the finely powdered potassium perchlorate, pour the resulting gunk into a mold, and allow to cool. The result was a tough material resembling nothing so much as "black-top" paving. This was the first castable, or "cast" propellant, and the new type of formulation—consisting of an oxidizer dispersed in a fuel matrix—became known as *composite propellant.*

The asphalt propellant had a number of desirable properties. Its performance was much higher, it could be stored more easily than black powder, and it could be molded to any shape and size desired. Unfortunately, it also had some undesirable characteristics. Being asphalt, it would begin to soften at temperatures of 110° or 115° F. and, if the temperature fell below about 32° F., it would crack because of brittleness.

As with any other solid propellant, there was a critical chamber pressure below which it would not burn efficiently. In this instance, however, that pressure was objectionably high—1500 pounds per square inch! To withstand such high pressure, the combustion chamber wall had to be heavier than was desirable in a lightweight motor.

One of the exhaust components was potassium chloride. As a result, the exhaust was a very dense, white smoke with approximately the same optical properties as a London "pea-souper". Everything in the vicinity of a JATO takeoff was effectively concealed—not only from the enemy, but from everyone else. Not only that: the potassium chloride had a nasty habit of depositing as a white coating on all nearby surfaces, including eyeglasses, bald heads, and airplane windshields!

By substituting an elastomer—a rubberlike material—for asphalt as the fuel matrix, the problem of high-temperature softness and low-temperature brittleness was solved. The improved propellant—a tough, resilient material somewhat like that of a tire tread or rubber heel—not only proved reliable from 150° to —60° F., but burned satisfactorily at chamber pressures down to one hundred pounds per square inch.

The substitution of ammonium perchlorate for potassium perchlorate, as the oxidizer, eliminated the dense exhaust smoke and increased the propellant performance. In damp weather, though, the exhaust formed a dense cloud of hydrogen chloride —hydrochloric acid—which was somewhat annoying, in a corrosive sort of way.

The performance of the new rubber propellant was approximately four times that of the black-powder used in the first JATO units.

While work on the JATO propellants was in progress, a parallel project to develop propellants based on organic resins was also underway, and a number of experimental rocket motors, of various sizes, were built and tested. Thrusts developed by these motors ranged from a few hundred pounds up to around 100,000 pounds—which may not seem like anything to write home about now, but was quite a sizable push in those days.

Another parallel development was that of nitroglycerine-nitrocellulose —double-base propellants. Double-base propellants belong to a larger class called *homogeneous* propellants, in which both the fuel and oxidizer are incorporated in the same molecule, as opposed to composite propellants which consist of a mechanical mixture of fuel and oxidizer. The molecules of homogeneous propellants, so to speak, contain the seeds of their own destruction.

Toward the end of World War II, the development of double-base propellants began with a ballistite formulation used for trench mortar "sheet" powder. When used in rockets, it was called JP—from jet propulsion. JP propellant was made up of 52.2 per cent nitrocellulose and 43.0 per cent nitroglycerine, with diethylphthalate, diphenylamine, and potassium nitrate accounting for the remainder. The diethylphthalate and diphenylamine were for plasticizing and stabilizing, respectively, and the potassium nitrate was to aid in maintaining smooth combustion.

It soon became obvious that a number of modifications of the basic

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ballistite formulation would have to be made before double-base propellants could be employed successfully in rockets. For example, there was the "wormhole" problem.

As a result of a number of unexplained motor blowups, an intensive study of the mechanism of propellant combustion was undertaken. One of the procedures used in the investigation of the manner in which a solid propellant burns is to stop the combustion by flooding the burning propellant with water, then study the partially consumed grain. If this is done at various stages of burning, it provides a pretty good picture of just what takes place from ignition until burnout. In the course of these investigations, it was discovered that small pockets back of the burning surface, i.e., within the mass of the propellant, had burned. These generally gave the appearance of worm holes, and the phenomenon became known as "wormholing." Later, when this work was reported in the literature, the effect was referred to as "termite fissuring," which sounds more "sophisticated."

Wormholing was, naturally enough, of considerable concern to rocket engineers. At best, it would result in nonuniform burning, and as long as it occurred, there was always the possibility that sufficient internal pressure would be generated to cause the grain to crack. When a grain is cracked, its burning surface is increased, and the resulting higher mass burning rate and more rapid production of combustion gases can —and often does—culminate in a motor blowup.

The obvious explanation of wormholing was that the propellant was not a perfectly uniform mixture, and that the material that burned prematurely was richer in nitroglycerine than the surrounding mass. This was all very well, but what initiated its combustion? Why did these little isolated pockets start to burn before the flame reached them? Ballistite is a poor conductor of heat. How, then, did the little pockets of NG-rich propellant—some of them at a considerable distance from the burning surface—get hot enough to ignite? It was certain that heat was getting from the burning surface to the interior of the propellant mass—but how?

Then someone remembered that heat can be transferred by radiation, as well as by conduction, and—presumably—also recalled that ballistite is normally more or less transparent to visible light. If it is transparent to visible light, might it not also be transparent to infrared: i.e., heat radiation? If this were true, any dark-colored material, such as a particle of dirt or other contaminant, might absorb enough radiation to cause a local temperature rise sufficient to initiate combustion. If the above assumptions were correct, anything that reduced the infrared transparency of the ballistite would eliminate wormholing.

It was known that ballistite is discolored by exposure to sunlight, and that prolonged exposure turns it a dark brown, thereby rendering it opaque—at least to visible radiation. Accordingly, some ballistite was exposed to the sun's rays until it was thoroughly discolored, then tested. Results showed a significant decrease in wormholing, so the practice became a part of the standard manufacturing procedure. Later, instead of exposure to sunlight, a very small amount—0.1 per cent—of nigrosine, a black dye, was added. Nigrosine was more effective, and its effect was more reproducible than that of sunlight. Still later, carbon black—0.2 per cent—was substituted for nigrosine—not because it was more effective in preventing wormholing, but because it had some desirable ballistic effects as well.

There have, of course, been motor blowups since, but—as far as known —none of them have been caused by wormholing.

There were a number of other problems that had to be solved, chief among which was the control of burning rate. Ballistite contained a lot more energy than either black powder or composite propellants, but its burning rate was too high. For gun propellants, it is desirable to have a high burning rate: the combustion of a rocket propellant must be considerably slower.

It should be mentioned at this point that there are two ways in which chemical explosions can proceed; by deflagration, and by detonation, often referred to as *low order* and *high order*, respectively. Deflagration is an extremely rapid burning, such as occurs when gunpowder is ignited in a cartridge or when a mixture of air and gasoline vapor burns in the cylinders of your auto engine. Detonation is exemplified by the explosion of dynamite or TNT. It results from a nearly instantaneous rearrangement of the atoms constituting the molecules of the exploding substance. In a rocket motor, we want neither deflagration nor detonation. What we need is a steady push—not a swift kick.

It had long been known that the velocity of explosion of NG-NC formulations can be regulated, within limits, by varying the proportions of NG and NC. This was tried, of course, but it didn't have enough effect. Luckily, during the long use of powder in guns, it had been learned that the mass burning rate—as measured by the length of time required to burn a given mass of propellant —depends upon the area of burning surface. Obviously, a fine powder has more total surface per pound than a coarse powder, so its mass burning rate is higher. Which is another way of saying that the velocity of explosion can be regulated by controlling the size and shape of the powder particles.

If you have ever removed the slug from a rifle cartridge, you will probably have noticed that the charge consists of small, cylindrical "grains." Most of us are accustomed to thinking of grains as small particles—grains of sand, grains of salt,

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et cetera. Charges for the larger artillery pieces, however, are made up of propellant grains more than an inch long and half an inch or more in diameter. Present-day rocket-propellant grains are truly gigantic: many of them will dwarf a man standing beside them.

The exact origin of the "grain" idea does not seem to be known, but the course of its evolution is fairly clear. Somewhere around A.D. 1400, "corned" or "lumped" powder came into use. Black powder was mixed with water, allowed to dry in a solid mass, then broken up into convenient-sized lumps for use in cannon. Shortly after the American Revolution, the use of presses to compress gunpowder into cakes for easy handling became general and, during the Civil War, the cakes—or *grains*, as they were later called—were perforated to give them a larger burning surface so they would burn faster.

In the very early days of rocketry, the black powder was compacted directly into the rocket "chamber"—which usually consisted of a cardboard cylinder—by tamping—essentially the same procedure as that used in making the first JATO units. It is doubtful whether those old-time rocketeers realized that compacting had any effect on the mass burning rate. It was probably just a convenient way of getting the powder to stay in the rocket. If it wasn't pounded in tightly, it simply fell out. Modern solid propellants are either cast in place in the combustion chamber, or first made into grains which are then inserted in the combustion chamber.

The development of longer-burning, hotter propellants introduced a serious problem: how to prevent the

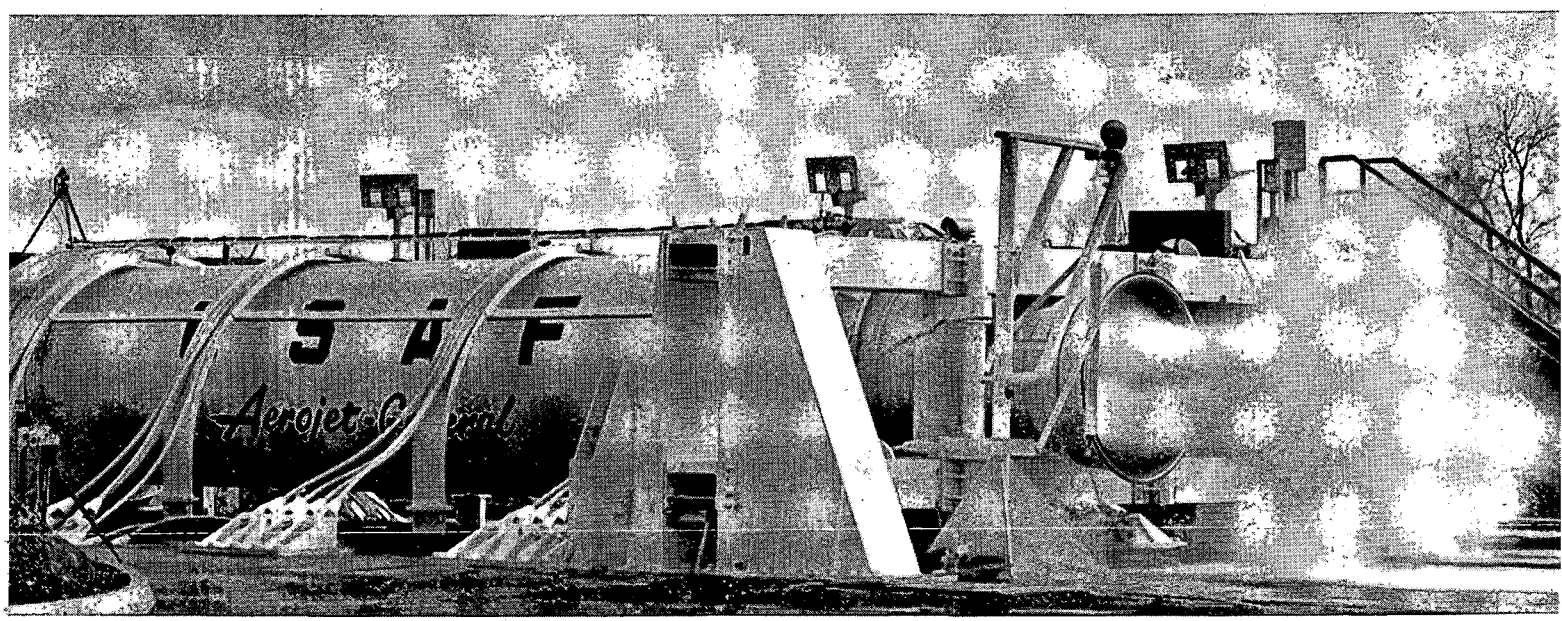

Fig. 7: A 100-inch diameter segmented solid-propellant motor ready for test firing. The motor is 53 feet long, weighs 119 tons, and develops a thrust of 600,000 pounds for 100 seconds. Smoke coming out of the nozzle is from the igniter which, itself, produces more thrust (50,000 pounds) than many of the "large" rockets of a few years ago. After ignition, the exhaust stream was 1500 feet long. Absence of moving parts in solid-propellant motors makes for simplicity and reliability.

Photo Courtesy of Aerojet-General Corporation.

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combustion chamber itself from burning through, melting, or failing structurally before the propellant was all burned. Most materials lose part, or all, of their strength at high temperatures. So, even if they didn't melt or burn, they could not be depended upon to withstand the high gas pressures generated by the burning propellant. This problem was solved, for the time being, in two steps.

During the development of the "rubber" composite propellants, which began in 1945, it was the practice to line or coat the inside of the combustion chambers with a corrosion-resistant material to protect the walls of the chambers from possible corrosion by the hot, molten propellant during the casting operation. The experimenters noticed that the propellant, upon solidifying, was bonded tightly to the chamber walls by the liner. This was not objectionable, since the bonding increased the structural strength of the motor assembly. Charges bonded to the combustion chamber walls are called *case-bonded*. Of course the bonded surface of the propellant could not burn, but the charge was of the end-burning type, anyway; that is, it burned in the same manner as a cigarette does—from one end to the other. This was fine for low-thrust, long-burning motors, such as JATO units, but the restricted area of burning surface would not permit a mass burning rate high enough for rockets requiring really high thrust. So much for the first step.

The second step—here the chronology gets a bit confusing—was taken in 1947, when it was decided to apply a piece of information that had been obtained from a British scientific mission visiting this country in 1940. The information had to do with the concept of burning a propellant charge from the inside outward. The idea had been developed by an English scientists, a Dr. Poole, in 1935. Apparently the rocket researchers had not been on speaking terms with the artillerists, inasmuch as powder grains had been perforated ever since the Civil War, and the "sliverless" grains used by the United States Army in mortars and howitzers had, for many years, been provided with, not *one*, but *seven* longitudinal perforations.

At any rate, by providing a hole—perforation—the length of the charge, thus converting it to what may be described as a thick-walled tube, the burning could be made to proceed radially outward from the inside surface. The unburned propellant, being a poor thermal conductor, acted as an insulator, thereby protecting the combustion chamber wall from the high temperature of the burning propellant. The larger burning surface permitted the design to be used for high-performance motors.

Under conditions of constant pressure and temperature, solid propellants burn in a direction perpendicular to the burning surface at a constant *burning rate* measured in *inches per second.* The mass burning rate, on the other hand, is measured in pounds of propellant consumed per second. So, if conditions are such that the burning rate remains constant, the mass burning rate depends on the area of the burning surface. The mass burning rate of an external-burning charge having a perforation of circular cross section will increase as burning proceeds because, as the hole is enlarged by burning, its surface—the burning surface—also enlarges. Motors using such grains or charges will show a thrust increase from ignition to burnout. If the perforation is star-shaped in cross section, the area of the burning surface remains about the same throughout burning—as burning proceeds, the cross section of the hole becomes more nearly circular—and the thrust remains nearly constant. The star shapes may have any number of points, and the "points" may not be pointed at all. If the star has four points, it is usually referred to as *cruciform*. There may be as many perforations—of as many shapes—as desired. Some grain designs are pretty weird!

Some high-performance motors, designed for extremely high thrust, employ internal-external-burning grains. Such grains, as the name implies, burn on both the outer surface and in the perforation. As combustion proceeds, the inner surface enlarges, but the outer surface becomes smaller in proportion, so the sum of the two surfaces remains the same. The thrust obtained in this manner is constant, and is about twice the thrust that is obtained by an internal-burning grain of the same size. When external- or internal-external-burning grains are used, the chamber wall must be protected by a refractory liner, unless the burning time is very short.

There are obviously an unlimited number of combinations of grain configurations and perforation shapes, each of which produces its own particular thrust curve. The study of various types of perforation and grain configuration as they relate to thrust behavior—charge geometry—has made it possible to design a grain, or charge, that will vary the thrust in almost any manner desired. This is called *thrust programming.*

Another clever little gimmick used by grain designers consists in cementing strips of noncombustible tape on portions of the surface to inhibit burning. This is, naturally enough, called *inhibiting*, and is often used in lieu of a too-complicated grain configuration to obtain some particular thrust characteristic desired. The ends of grains are usually inhibited to restrict burning to the perforation or the outer surface—or both—as required.

TO BE CONCLUDED

The Great Fuel Feud is too extensive for a one-article presentation. Next month the second section, devoted to liquid, or "leaky" propellants as the solid-fuel advocates prefer to call them, will follow.

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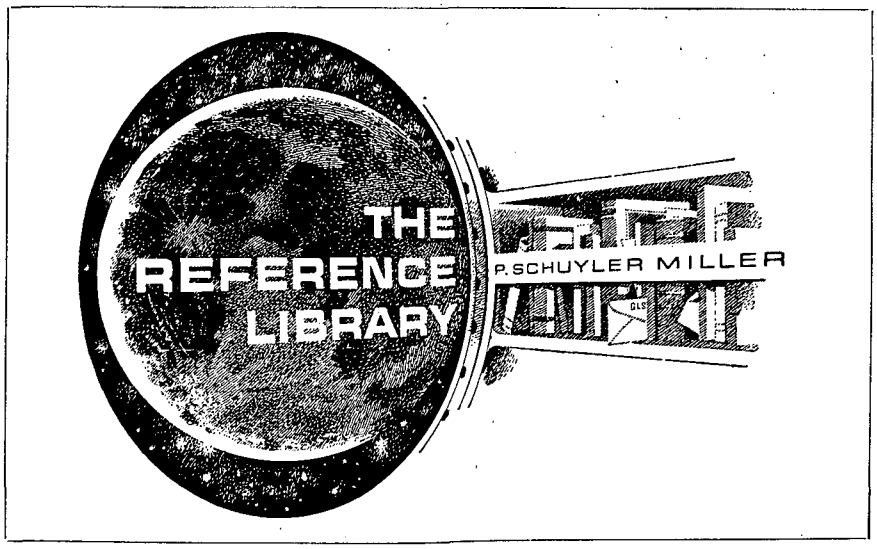

CRAZY KID STUFF

It is every bit as hard to define the place of juvenile science fiction within our field as it is for a teenager to decide what his place is in our society. I have no intention of trying to remedy either situation here—just to point to the nature of the confusion and document it, as I do from time to time here.

To many "men in the street" *all* science fiction is "crazy kid stuff." They point to the monster movies and monster or marvel comics—the latter a field in itself that I am far from competent to discuss—as proof of their stereotype. At the same time adult magazines are serializing books about teenagers, written by Robert A. Heinlein and commissioned by major publishers for their "YA" or "young adult" lists. Some of these are better than the books he is writing as adult fare. Meanwhile Andre Norton, an extremely accomplished writer of juvenile adventure fiction, is reversing this process: *her* "juveniles" are later reprinted as adult paperbacks. They also set a level of quality for stories of their kind—colorful interplanetary adventure of the best sort.

Those of us who are old enough to have been brought up on the "Tom Swift" books find that the series books have not died out. I haven't had time to check up on "Tom Swift Junior" in the last couple of years, but he is still there, and other series for the younger teen-age set are muddling around with relatively elementary SF themes. Meanwhile Donald Wollheim, fan, writer and editor, has launched a new series—the "Mike Mars" books—with a unique character of their own.

Getting down to the grade-school years, still other writers are turning to what I'd call "pretend" science fiction. What would once have been a talking bear is now a talking critter from the planet Zilch. A frammus-wibbler is evoked to handle miracles that a magic wand or a good hard wish once took care of. The trappings are there, but rarely the mood or the substance of what we look on as science fiction. Yet what's the *real* difference between a man who walks-through walls in Analog and a child who does it in a tale for ten-year-olds?

Just about the whole range of type and quality is spanned by five late-1962 and early-1963 books that I have been reading. By all odds the most unusual, hardest to classify, and best job of writing by any standards is Madeleine L'Engle's "A Wrinkle in Time"—211 pages, $3.25, published by Farrar, Straus and Cudahy as one of their "Ariel Books" for ages "12 and up." Miss L'Engle is credited with six other children's books, two of them high on "best" lists and one of them science fiction. Here, never "writing down," never condescending, never failing to abide by the kind of rules that the adult science-fiction field has laboriously worked out for itself, she has done a story that makes the most tarnished stereotypes shine again.

"A Wrinkle in Time" fits, if it has to be fitted anywhere, into that small company that includes C. S. Lewis' "Perelandra" triology. It uses fairy-tale elements matter-of-factly and makes them plausible, if other-worldly science. It squares away at the unfashionable theme of Cosmic Good and Cosmic Evil, which even religion treats somewhat abashedly these days. It does all this with style and characterization and everything else that a very accomplished writer has at her fingertips.

Yet the plot elements, pulled out and examined anatomically, are over-familiar. A mathematician, experimenting with fifth-dimensional transportation, has disappeared. His plain, high-school-age, thoroughly ordinary daughter and her very young, very precocious, occasionally telepathic brother set out to do something about it, aided by an ugly-duckling schoolmate and three strange old ladies who turn out to be three rather remarkable extraterrestrials. This ill-assorted crew "tesser" across the Galaxy from world to beautiful or terrible world, and come at last to Camazotz where a master brain keeps every man, woman and child under the strict regimentation of an utterly orderly, utterly horrible society. Here the children's father is held prisoner in a kind of stasis; here they have to act heroically in little ways in order to win in a big way. And back of it all they get glimpses of a universal evil which all creatures of good will, whether they be winged centaurs or furry star-beasts, must always fight.

If you like Lewis' unorthodox approach, you should find "A Wrinkle in Time" remarkable. If you consider his books nonsense, leave it to "12 and up."

Robert Heinlein has a unique place in science fiction, and too few of his followers have read his dozen

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or more "YA" books, several of which are better than some of his adult novels, including the "Hugo" award winning "Stranger in a Strange Land." His new book for G. P. Putnam's Sons, "Podkayne of Mars"—191 pages, $3.50—was serialized in *If*, yet it is openly a juvenile and not one of his best.

Podkayne of the title is a little over eight in Martian years—sixteen by Terran reckoning—born and bred on Mars and very sure of herself. The thorn in her flesh is a kid brother Clark, older than Charles Wallace of "Wrinkle in Time" but very brilliant in his own right, and quite insufferable to older sisters. With the aid of a politician uncle they finagle a vacation trip to Earth via Venus, and are presently up to their ears in melodrama—but unfortunately melodrama without suspense. Podkayne is too self-conscious a heroine to make her views of things more than amusing, or the events in which she is involved of much importance.

There is one exception, as there is bound to be in a Heinlein book: a chapter near the middle in which Podkayne, with matter-of-fact teenage competence, wades into the hullabaloo of a spaceship load of babies floating in free-fall. While she is involved in this, Podkayne is a real person—and the emblem of the host of young people of sixteen who do cope without getting into the papers. Her Mars-centered views elsewhere in the book are amusing, and the logically strange interplanetary society is painted in behind gauze curtains with the infallible Heinlein virtuosity, but Podkayne does not belong in the company of the "rolling" Stones or the young friends of the "Star Beast" whom we met in earlier Heinlein juveniles.

I've commented before on the four books with which Donald Wollheim launched his "Mike Mars" series. The fifth in the series, "Mike Mars Flies the Dyna-Soar," is tagged by Doubleday "up to 14"—188 pages, $1.25 of all things!—and that is just about where it belongs, filling the spot solidly and worthily.

What distinguishes the Mike Mars books from, say, the new "Tom Swift" series is their air of unmistakable authenticity. As the story has it, the U.S. is training a secret corps of younger astronauts to do everything the on-stage company will do, and in the absence of two-a-day performance commitments, do it sooner and better. Mike Mars and his Cheyenne Indian pal, Johnny Bluehawk, went through a lot of purely formula melodrama in the first four books, but *they* were in orbit before the adult team. And with the co-operation of the Air Force and a good deal of on-the-spot study, the author makes the details thoroughly convincing, as Mike uses the Dyna-Soar glider to get Bluehawk down out of orbit.

On the other hand, the English amateur astronomer and science popularizer, Patrick Moore, gives us purely routine boys' adventure—English variety—in "Crater of Fear," $2.95 from Harvey House. This appears to be the second or third book in a series about adventures on the Moon, but the first to be published in the United States. It was apparently preceded by a five-book Mars series.

The gee-gosh adventures of Robin North, Rex Redmayne—yes, he has red hair—and Nicholas Valinsky are a notch more mature and believable than the equally heroic adventures of young genius Chris Godfrey in the other series by Hugh Walters, which immigrated from England a few years ahead of Moore's yarns. In the earlier books the principle of international scientific co-operation on the Moon seems to have been thrashed out—but now both the West and the Soviet turn out to have secret armed bases on the hidden backside of the satellite, from which their own scientists are barred. Naturally North, Redmayne and Company go to snoop, naturally they hear an S O S, naturally they crack up while attempting a rescue, naturally they triumph over all the various sets of Bad Guys after many heroic hardships.

The main scientific theme of the book is the same moon dust idea that Arthur Clarke did up so thoroughly in his "A Fall of Moondust." Moore can't be blamed for making the switch for a young teen-age audience, but did he have to hoke it up with such implausibilities as a kind of solar radiation that accelerates the decomposition of radium to the explosion stage?

Just for the sake of the record I'll close the list with still blander fare, again by a professional writer of young people's books, which originally came out in 1958 and has now been reprinted in Grosset & Dunlap's new series of "Tempo" paperbacks for teenagers. It is No. T-9, has 192 pages, costs 50 cents. "Mystery of Satellite 7" was on its toes in 1958, with the idea of a civilian program to get a communications satellite—the Argus—into space. Three teenagers, sons and a daughter of Project Argus scientists, pretty well have the run of the place and when it seems clear that sabotage is behind the continued failure of the Argus shots, they are quick to say "Ahah!" Yet when mysterious and menacing strangers start popping out of the bushes on a nearby island, they can't quite see the obvious—until enough pages have been turned to bring the thing to a head with capture, threats of death, a last-minute rescue attempt, et al.

Charles Coombs has certainly been in the business long enough, and earned enough of a reputation with juvenile books, to have gotten the kind of co-operation Don Wollheim did—if he had gone out after it. On the whole, his book is probably smoother and more professional than Wollheim's "Mike Mars" adventures—but they just don't have that ring of authenticity. And that, it seems to me, is something we should expect of any juvenile science fiction offering in these enlightened days. Even when you are writing about worlds of singing centaurs on the other side of a wrinkle in Time, like Madeleine L'Engle.

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ANYTHING YOU CAN DO . . .
by Darrel T. Langart
Doubleday & Co., Garden City, N.Y. 1963. 192 pp. $3.50

I hardly need describe the plot of this adventure puzzle, since it was serialized here last year in a somewhat shorter version. I think it is just to call it a "typical" Analog story—a fairly monstrous extraterrestrial, the Nipe, whose rigid code points up the truism that our values aren't the only values . . . a somewhat technical problem to be solved, in how to get to him without being got . . . a puzzle of values, not too difficult, in the question why the thing hasn't long since been blasted out of its nest under New York . . . and a behind-the-scenes, wheels-within-wheels touch of van Vogtian complexity to keep you doubting that you have really figured out what is going on.

The book won't be a landmark, but it is better reading than most. If you didn't read the serial, and don't think any book is worth $3.50, wait for the paperback.

BURROUGHS BONANZA

While he was writing them, Edgar Rice Burroughs was content to bring out two of his adventure fantasies a year as books, with a few more in the magazines. Now that some of his earlier stories have fallen into the public domain, a battery of publishers are showing far less restraint. If there *is* a market for fifty-year-old Burroughs yarns, everyone wants to be first in the field. The result is already an avalanche, and it may choke itself off. Meanwhile, I'll try to keep up with the reasonably science-fictional portion, excluding Tarzan and the innumerable lost civilizations that he turned up all over Africa.

Ballantine, new in the field, has launched a series of *authorized* paperbacks with the first two in the Mars series. If the adventures of John Carter sell well, others will be tried. They're using a realistic artist, Robert Abbett, for their covers.

Canaveral is abandoning its Mahlon Blaine illustrations, which were about as off-key as you could get, for the work of other artists who can approximate the style of the original J. Allen St. John illustrations, and have reproduced the St. John originals for the first of the Venus series. Dover, which started the stampede almost a year ago, has announced three omnibus titles for early March: the first three "Pellucidar" books in one volume, the first two Venus titles in another, and "Moon Maid" and "Land That Time Forgot" in a third. Ace is continuing with its assorted reprints, with colorful covers by good new artists.

Athough I intend to skip the Tarzan reprints, don't forget that the "lost civilization" or "lost race" theme was at one time a much-used and perfectly respectable science fiction theme, up to the point where there were no more places in which civilizations could be hidden.

As a general rule, only the first reappearance of Burroughs titles will be noted here; the rest will show up in their proper place with the other reprints. I'm making some exceptions in this roundup for editions which appeared in hard and paper covers almost simultaneously.

A PRINCESS OF MARS
by Edgar Rice Burroughs
Ballantine Books, New York.
No. F-701. 1963. 159 pp. 50¢

First of the Mars series, and still good reading if you forget that it was John Carter's astral body that was projected to Barsoom—Mars—in 1866, arriving bouncy and muscular but without clothing. This was Burroughs' first published story, serialized in 1912. By dropping Carter among the monstrous green men instead of the "ordinary" human beings he meets later, and by cramming this and the next two books with detail after bizarre detail, Burroughs successfully obscured the fact that his plots were so trite and coincidence-crammed as to be practically Shakespearean. Here you meet all the basic characters: Carter himself; Tars Tarkas the green man, eventually *jeddak* of the hordes of Thark; the beautiful Dejah Thoris, John Carter's bride-to-be and granddaughter of the *jeddak* of Helium; Woola, the faithful watch-*calot*, who is the most sympathetic character in the series; and many another. At the end, Carter is snatched back to Earth just as he is about to save Mars. Burroughs ran this cliff-hanging device into the ground, but the readers loved it!

THE GODS OF MARS
by Edgar Rice Burroughs
Canaveral Press, New York.
1962. 348 pp. $2.75
Ballantine Books, N.Y.
No. F-702. 1963. 190 pp. 50¢

Twenty years after his first trip and ten after the close of "Princess of Mars" John Carter makes a new astral trip to Barsoom and lands in the midst of the Martian "heaven" in the sunken Valley Dor at the South Pole. More novelties and color are packed into this book than in any of the others—and there is another cliff-hanger of an ending that demands a solution in No. 3, "The Warlord of Mars," next on the Ballantine list.

Canaveral used a not very good new artist, Larry Ivie, for their hardback. Ballantine is using a realistic cover artist whose name I can't read. He isn't St. John, but he has the same literal touch.

PIRATES OF VENUS
by Edgar Rice Burroughs
Canaveral Press, New York.
1962. 314 pp. $2.75
Ace Books, N.Y.
No. F-179. 1962. 173 pp. 40¢

Having staked his claim to Mars, Burroughs moved in on Venus with this book in 1933. Carson Napier, heading for Mars by rocket, makes a classic miscalculation—he forgot the Moon—and lands on Venus instead. Twenty years after the first Mars book, wonders and adventures were getting to be old stuff, and the series hasn't the *zing* of the first John Carter yarns—or the early Tarzan, for that matter. Monsters, tree cities, pirates,

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double-talk science—the formula is standard.

Canaveral has reproduced the original J. Allen St. John illustrations, except on the jacket. Ace has another version of the St. John frontispiece by Roy Krenkel, Jr., one of the two real discoveries among the new Burroughs illustrators.

TANAR OF PELLUCIDAR
by Edgar Rice Burroughs
Canaveral Press, New York.
1962. 245 pp. $2.75
Ace Books, N.Y.
No. F-171. 1962. 224 pp. 40¢

Third in the series about the physically impossible world inside a hollow Earth, inhabited by intelligent reptiles and all manner of flora and fauna that have survived from earlier geologic eras. David Innes, back inside the Earth and rebuilding his empire of noble primitives, is attacked by the Korsars, dastardly sea-rovers whose ancestors sailed in through a hole at the North Pole. The action is carried by a young Pellucidarian, Tanar, who does a lot of exploring and escaping. The Mahlon Blaine illustrations for the hardbound Canaveral edition are about the best he has done for them. Ace has a far better Krenkel cover and title page drawing. The book introduces Jason Gridley, a California inventor who ties all Burroughs' series together.

TARZAN AT THE EARTH'S CORE
by Edgar Rice Burroughs
1962. 301 pp. $2.75
Canaveral Press, New York.
Ace Books, N.Y.
No. F-180. 1962. 223 pp. 40¢

"Tanar of Pellucidar" ended with David Innes in a Korsar dungeon. Jason Gridley builds a super-dirigible filled with vacuum, persuades Tarzan to come along, and they fly in through the hole at the Pole to rescue Innes. Everybody gets separated from everybody, and Tarzan and Gridley carry the action. This one has some nasty lizard-riding reptile-men, the Horibs, and a member of the German crew stays lost to investigate two more books. The Canaveral edition has some particularly good illustrations by another new artist, Frank Frazetta, who also did the Ace cover and title page. The Canaveral editions of both these books have more illustrations than the original editions.

THE CAVE GIRL
by Edgar Rice Burroughs
Canaveral Press, New York.
1962. 323 pp. $2.75

Very minor lost race stuff, on the inevitable lost island in the Pacific. Waldo Emerson Smith-Jones, scrawny Boston beanpole, is shipwrecked on said island and makes like the epitome of all mother's darlings until he meets the cave girl, Nadara, whose buxom form stands on Krenkel's jacket and is chased back and forth through the illustrations. Ashamed of his puniness, Waldo takes six months off and becomes a physical colossus. Everybody slugs everybody else, and Boston proprieties are satisfied when Nadara turns out to be a castaway Countess. The serial version dates from 1913 and 1917, and so do the plot and style.

THE LAND THAT TIME FORGOT
by Edgar Rice Burroughs
Canaveral Press, New York.
1962. 318 pp. $2.75

This is Burroughs' "farthest out" book, first published as three novelettes in 1918 and reprinted in *Amazing Stories* in 1927 after at least two hardback editions had come out. A German U-boat—submarine to you, junior—is captured by the crew of an English ship it has sunk. Through dastardly devices, it winds up in the South Pacific and finds a lost world with the most remarkable fauna ever invented. Each creature starts life as a tadpole which makes its way up the entire evolutionary scale—fish to amphibians to reptiles to mammals to apes, and eventually to a nicely graded series of human races. Anyone may stop at any stage, but a few make the whole tour and as a prize may then bear children directly instead of laying frog-eggs in the nearest hot spring. Then there are winged ghouls who are a notch above the heroine-type Galu. Mahlon Blaine tried to draw 'em.

CURRENT REPRINTS

AT THE EARTH'S CORE
by Edgar Burroughs
Canaveral Press, New York.
1962. 159 pp. $2.75

PELLUCIDAR
by Edgar Rice Burroughs
Canaveral Press, New York.
1962. 180 pp. $2.75

New hardcover editions of the first and second Pellucidar books about an—impossible—world inside the Earth. The Mahlon Blaine illustrations are a shade better than for the previous Canaveral titles.

THE CHESSMEN OF MARS
by Edgar Rice Burroughs
Ace Books, New York.
No. F-170. 266 pp. 40¢

Fifth of the Mars series. Art—good—by Krenkel.

THE TOMORROW PEOPLE
by Judith Merril
Pyramid Books, New York.
No. F-806. 1962. 192 pp. 40¢

Pyramid's line gets longer and better. A realistic novel of the psychological problems of the people who go into space.

THE WAR AGAINST THE RULL
by A. E. van Vogt
Permabooks, New York.
No. M-4263. 1962. 187 pp. 35¢

Early van Vogt, welded together from the stories that first appeared here in Astounding in 1940-1950, and far more readable than his more ambitious—and confusing—later books.

THE HUMANOIDS
by Jack Williamson
Lancer Books, New York.
No. 74-812. 1963. 178 pp. 75¢

Another classic, with a more basic problem for our automated times than sociologist Wells raises.

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BRASS TACKS

Continued from page 5

The Journal of Scientific Controversy is a quarterly journal devoted to the publication of new or controversial ideas from any field of science and technology. The first issue—coming out in the second quarter of 1963—will include articles on:

The Crehore All-Nuclear Atom
A Proposed Structure for Ball Lightning
Feedback and Feedforward Mechanisms in Culture
Drag at Velocities near that of Light
Optical Effects of Exceeding the Velocity of Light

Other features will be:

The Information Center: We will publish questions, data, or requests for information from the readers. We will act as a clearing house for hard-to-get information, and help people who need help from other specialties to find it.

Shorter Notes: This will consist of smaller items, summaries of work, and notes on work in progress.

Discussion: Comment and author's replies on articles.

This is no mimeographed "quickie." It is a serious venture and will be well printed on good paper. We will accept subscriptions: $1.25 per copy; $4 for the year (4 issues).

You, John, have been talking for some time about all the people in this country whose ideas are shoved aside and ignored. Are they really out there? Do you think that there are enough people willing or able to put controversial ideas on paper and have them published, *and* willing to expose themselves to the heresies of others, to support this journal?

I am not sure, but I am going to try like hell to find out.

WILLIAM REID, *Editor*
The Journal of Scientific Controversy
P.O. Box 855,
Boulder, Colorado

■ *Perhaps it should have the alternative title "The Journal of Scientific Hammer and Tongs"?*

Dear Mr. Campbell:

I read with interest and apprehension the maritime worker's letter in the November issue of ASF. I certainly hope that he is not typical of our maritime workers for he demonstrates a barbarian level of thought, unworthy of modern Americans.

His letter provides evidence that the dictum, "Power corrupts and absolute power corrupts absolutely," needs to be revised. It should be: Money above one's fair share corrupts and the amount of corruption is directly proportional to quantity above fair share and inversely proportional to genetic endowment and quality of experience, or:

Where $C = \frac{\$ - F}{GE}$

C = Corruption
$ = actual income
F = Fair share income
G = Genetic endowment
E = quality of Experience

It is readily apparent from the above formula that a person receiving less than his fair share is corrupted negatively. Perhaps this explains the negative thinking so often found among intellectuals in the United States.

I think everyone should examine his profession and work habits every-once-in-a-while and ask himself, "Is this really the best way I can assist total human welfare and progress?"

ROBERT SAXTON
405 N Marengo,
Pasadena, California

■ *Ah—a real contribution! "The Unfair Share Formula!"*

Dear Sir:

Your reply to reader Slattery in the November issue was quite impressive. I especially liked that part where you say, "we have to find that 0.0001% of cranks who are geniuses—because there is no other way." Then I began to wonder. Does John Campbell himself believe that? He says it, but does he *believe* it? Isn't this an open invitation to every crank who sees it to tell this wonderful understanding man all about his message to the world? I can see it now. The undaunted hero burning the midnight oil, wading through his avalanche of fan mail, sifting through 1,000,000 pieces of crackpottery, his head bloody but unbowed, true-blue, and foursquare, searching for that exceedingly rare and valuable jewel—the genius-type crank and his great contribution to mankind. It gets me all choked up. Then the vision fades and I see a practical hard-headed editor, with a flair for inspiring words and a heaping wastebasket. The picture isn't as appealing, but somehow it seems more convincing.

JAMES KEENEY
256 East Broadway,
Salt Lake City 11, Utah

■ *Thanks for calling this attitude to my attention; I had not realized the problem your intended-to-be-sarcasm indicates. You are, presumably, a scientist-technician; to you, the idea of culling hundreds of pages of crackpottery to find a few useful germs seems obviously impossible—as, apparently, it does to nearly all scientists.*

What you have completely failed to realize is that THAT IS PRECISELY WHAT AN EDITOR NORMALLY DOES!

To me, because that is the nature of my life-work, the possibility and entire practicability of doing what you suggest is "perfectly obvious"; I've been doing it as a routine way of life for twenty-five years. I personally read every manuscript that every author and would-be author sends in—because there is no other way to find the new authors with new ideas. Not only is it necessary to find the good stories buried among the crackpot efforts, but it is necessary for an editor to find the authors who can't write yet—and encourage them, help them, until they do succeed.

Your sarcasm misses—simply because you have quite correctly and accurately described what an editor expects to do for his living.

Sorry scientists aren't as tough-minded and persistent as editors.

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EDITORIAL

Continued from page 6

vague references to "present progressive" and such things . . . which don't happen to apply. The main difficulty with modern grammar studies is that they derive, historically, from the old studies of Greek and Latin grammar; it just happens they don't apply to English and some of the other modern languages.

Notice that no one who really speaks English would say "I am seeing what you mean," nor would he say, "I can't come now; I wash my hair." To anyone who grew up with English those mistakes are screamingly obvious . . . and yet you can't cite the rule that they violate! Some verbs *never* take the "I am . . ." form in the present active sense; "to see" is one, but there are many others. Others, however, *always* do, in the present active sense; "to wash," as above, is one.

And there is a definite rule which native-born English speakers know subconsciously, but not consciously. They can invariably choose the correct form, even on an unfamiliar verb—and yet can't specify the rule.

This makes learning English very simple for the nonnative, of course. The teacher doesn't even know why what he says is said that way!

I've had fun dreaming up English grammar test questions to be given to professors of English grammar. Like "What is the infinitive form of the verb in the sentence 'What hath God wrought!' ?" And "What is the mood and tense of the verb *be* in 'Be he live or be he dead! '?" Or other interesting items such as "Shakespeare never used the word 'yes,' and no author of his time or earlier used it. When was the word 'yes' introduced into English?"

Oh, there are several thousand reasons why English should never be an international language. Obviously, a language so irrational, so complex, and so indefinite in what it's trying to do would never spread.

Only it did.

Meanwhile, conscientious and dedicated efforts to perfect an international language—a carefully and logically constructed language—have been going on for nearly a century now. One of the oldest and most solidly promoted, Esperanto, has reached a point where most educated people today have heard that it exists. Its grammar, spelling, and vocabularly are logical, consistent, and based on a relatively few invariant, reliable rules. One of its rivals, Interlingua, has even simpler grammar, and a vocabulary deliberately based on the common root-word forms of the great European language group, so that it can be read with fair ease even by people who never saw it before. . .

But Esperanto remains an intellectual hobby, not an international language. Interlingua is making some progress as a scientific international language—again strictly an intellectual achievement—but nobody *talks* either one.

The latest contender in the artificial language field seems to be *Loglan*, a deliberately logical language —essentially a computer language, simply verbalizing Boolean algebra into a language. Magnificently logical . . . and nobody is going to learn it save as a highly intellectual hobby. People aren't even going to learn it, or equivalents, to talk to computers; they're going to have to make computers understand human beings before men are satisfied.

The reasons why none of the international designed languages have succeeded, and why English has are, evidently, not in the area of "logical explanations"—because the logic of the thing is wholly in favor of Esperanto, Ido, Interlingua, et cetera, and the success in international speech is entirely in favor of the nonlogical natural languages.

People tend to hold that "reason" and "logic" are equivalent; the fact definitely is that they are not; a thing may be entirely reasonable, and totally nonlogical, within the meaning of the term "logic" as normally used. (Acting on a hunch is reasonable many times—but is never *logical*, because, by definition, a "hunch" is a belief that cannot be supported by logical evidence.)

All of these factors seem to me to build up a pattern indicating an area where some extremely valuable and important research could be undertaken. Human language is, very specifically, a product of human mind—as much so as an egg is a product of a chicken. And that analogy is used in the full recognition of the ancient which-came-first problem.

It makes no difference which you choose to say came first, language or mind, the fact is that language is available for study in a degree that mind is not—and it needs studying to find out *what it is*, not *what we think it ought to be*.

Our whole approach to study of anything has, for the last couple thousand years, been squeezed into a strait jacket of true-false logic—and that simply isn't an adequate method. To illustrate what I mean, let's see some of you mathematical logicians try to express, in formal true-false logical terms, the following statement—which can't be so expressed, because it is a typically human, rational, nonlogical statement: "I don't care whether what you say is true or false; I will have nothing to do with it!"

All the formal logic we have worked with has assumed that Truth *was always important*. It isn't—which makes the logician find that he has proven the truth of a proposition conclusively, but everyone around him says "I don't care whether it's true or false—I'm not interested."

Seemingly, Esperanto, Interlingua, Loglan, and all the other conscious-

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ly logical international would-be languages have achieved the Logician's Plight—"We don't care whether it's logical or not . . . we're not interested."

The synthetic languages have all failed to achieve the critical part of the task—*getting people interested!* They may satisfy logicians-as-logicians, they might satisfy computers, but they clearly don't attract human attention.

English, despite all the apparent reasons for rejecting it, *has attracted and interested human beings.*

English, as a language, had a unique history. England's major recorded history starts with Picts and Britons being conquered by Romans. Eventually the Romans retreated—but what they'd done in the way of imposing a new linguistic concept didn't retreat southward with them. For several generations, anybody who was Anybody in the area spoke Latin—only the demeaned peasants spoke the old home language. The intellectuals, the Defenders of Educated Tradition were busy showing off their Latin.

When the Romans left, the old language and Latin got sort of scrambled a bit—not so much words, as ways of saying things, turns of phrase and concepts.

After the Romans left, there was quite a series of invaders: Angles — Saxons — Vikings — Norman French. Each time, the native language was pushed into the demeaned class, and the Defenders of Educated Tradition were busily defending something else . . . only to have that other language in turn depressed to the peasant-rejected level in turn.

By the time this series of grinding-down operations was finished, English had been stripped very thoroughly of all nonfunctional grammar. No traditional beauty remained, but there was a time-and-use tested hard core of grammatical structure that produced maximum communication of human-living importances with a minimum of formalism. The demeaned peasants weren't long on logic, but they had lots of experiences with human-living problems, and they worked out a language that would say what needed saying—and to hell with noble logic and traditional grandeur! The careful declension of nouns and adjectives and agreement of case and number had, somewhere along the way, been found unnecessary—and who worries about the noble traditions of a demeaned peasant-language?

Somewhere, they found you could get more ideas across with fewer components if you made word-order more important and case-endings less so. Things like "Only John saw him go," "John only saw him go," "John saw only him go." "John saw him only go," for instance.

English was stripped, generation after generation, conquest after conquest—but somehow persisted, underneath the varying current Noble and Proper Educated Languages, whatever they might be at the moment.

And, amazingly, in the process English developed a kind of subtlety that no other language ever discovered! The English verb-forms, for instance, can not be quite exactly translated into any other language. Oh, the logical near-equivalents exist, but there are subliminal processes implicit in English that the grammarians haven't even discovered yet!

For instance, that business of the varying present active tense of English verbs. I used an artificial verb, "to larb," back there. You've never heard the verb, yet if I give a definition for it, you will know the correct—and the *only* correct!—present active tense form. Let's say that "to larb" means to set the dials, punch the buttons, and plug in the circuit connections to set up a computer for solving a problem. If that's the mean-

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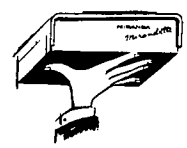

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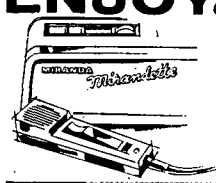

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EDITORIAL

Continued

ing, would you say "Don't bother me now; I larb the computer," or "I am larbing the computer?"

Why should it be "I see what you mean," not "I am seeing what you mean?"

The rule is very simple—and very subtle. "A verb of objectively observable action takes the "I am . . ." form; verbs of *subjective action* take the "I . . ." form. Some verbs are used in both senses; in those instances, the form used serves to distinguish which sense the speaker intends. Thus Rodin's "The Thinker" might say, "Don't bother me; I'm thinking," but normally we say "I think it will rain."

Trying to derive modern language grammar from the archaic grammars of the dead languages, Latin and Greek, sends research off in wrong directions.

For instance, the Latins had no word meaning "yes,"; all modern languages do. But even here English is unique; we have several forms . . . *and they are not synonymous.* Shakespeare never used "yes"; the word had not been introduced into the language in his time. He used "aye"—which is used today only in special and limited sense. You may not be consciously aware of your knowledge—as you probably weren't consciously aware of that rule of English present-tense forms—but you know subliminally that "aye" and "yes" do *not* have the same meaning.

Today, "aye" is most commonly used in Parliamentary procedure—"All those in favor vote 'Aye'," is the familiar form. It's also used as an acknowledgment of an order. But the specific difference is, again, a subtle but highly important human manner. "Aye," specifically implies a *volitional* agreement; "yes" implies simply objective agreement. That is, "If I shove you off the roof here, will you fall?" has the answer "Yes," but not ordinarily "Aye," unless it is addressed to an intelligent and cooperative birdlike alien.

A man may accept the order of a superior officer with "Yes, sir," and express his disapproval of the idea—or with "Aye, aye sir!"

The trouble with the efforts at international languages lies, apparently, in their failure to study what *more than logic* a human language must be able to communicate . . . and why!

Part of the difficulty stems from the immense difference between a logical analysis and that-which-was-analyzed.

For example, a human being can learn to whistle almost perfectly pure sine-wave tones. It would be fairly easy to design a computer-input that reacted to a complex sequence of sine-wave tones—in essence that's what the modern telephone dialing gimmick does; you've heard the *tweet-twee-twoo-teet* tune they play—much more readily than to the ragged wave-forms of human speech.

But people aren't going to like being cut down to whistling unmusical tunes to make things easy for a computer-designer.

Now it is a fact that a human being can't sing a chord—but while highly trained singers can learn to sing almost perfect sine-wave notes, most human beings produce a vast assortment of complex wave-forms. The physicist, trying to analyze those complex waves, says "This wave *is made up of* a complex series of sine and cosine waves."

He's wrong; it isn't made up of a complex series of sine-and-cosine waves. I've seen what a physicist needs to duplicate that wave by setting up sine-and-cosine-wave generators, interlocking them, combining their outputs, and generating the desired wave. It takes a mass of electronic hardware that looks like a major computer—and is!

The physicist is making the egregious error of saying that the wave *is made up of* those complexities, because it *can be analyzed* in that way.

This is about equivalent to saying that a cow is made up of sirloin steaks, hamburger, tripe, shoe leather . . . et cetera and neglecting to consider the organic structure of the animal.

While a human being can't sing a chord—he can produce a vast variety of highly individual wave-forms. And because the wave-shape is perceivable to human hearing mechanism, the frequency or tone, becomes relatively unimportant because it can carry so little information, while wave-form becomes extremely informative.

Forcing a human being to cut down his communication to a sine-wave whistle, therefore, annoys him, and quickly turns him to some more satisfactory, more rapid, communication medium.

And the international languages structured entirely on logic are doing an equivalent thing. My challenge statement for the logicians above, "I don't care whether it's true or false, I will have nothing to do with it!" is simply a long-way-round way of saying "Yes, but I don't like it."

The international language efforts have failed, I believe, because they haven't provided a channel of communication that was wide enough for a *man* to walk through. Only his logical one-dimensional shadow-of-a shadow could get through—and the man got disgusted and went somewhere else.

For years now people have been pointing out reasons why English and other natural languages are illogical, nonsensical, whimsical, irrational, and everything else undesirable.

I urgently suggest that it is time for someone to take a new look—and find out why the natural languages are so enormously superior *in living fact* to any and all would-be synthetic languages.

We might learn a very great deal about the nature of Mind, if we could put aside our prejudices long enough to make an honest study of Mind's greatest product—language.

The Editor

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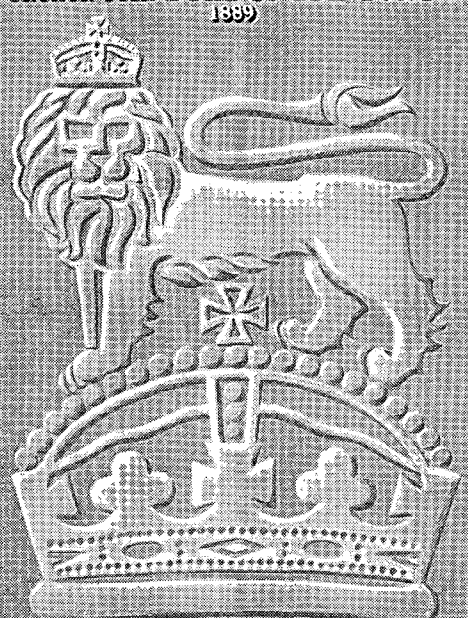

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